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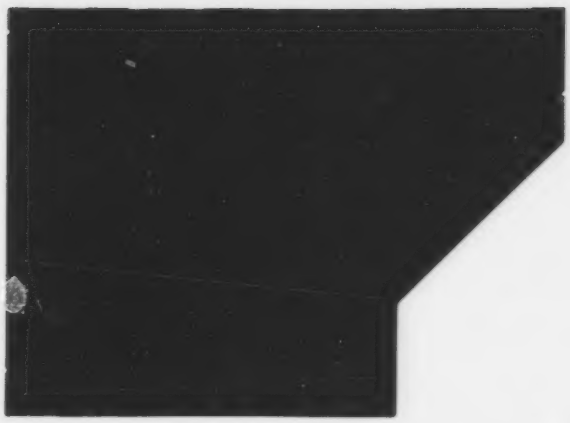

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PROJET DE RECHERCHE SUR LE BRUIT D'APPAREILS MÉNAGERS DANS LES IMMEUBLES MULTI-LOGEMENTS

PROJET DE RECHERCHE
SUR LE BRUIT D'APPAREILS MÉNAGERS
DANS LES IMMEUBLES MULTI-LOGEMENTS

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Le 31 mars 1992

Société canadienne d'hypothèques et de logement
Division de la mise en oeuvre des projets
682, chemin de Montréal
Ottawa (Ontario)
K1A 0P7

À l'attention de Monsieur Jacques Rousseau, directeur des projets

OBJET: **RAPPORT D'ÉTUDE** (Projet DCI: P-91-029):

Projet de recherche
sur le bruit d'appareils ménagers
dans les immeubles multi-logements

Monsieur Rousseau,

Vous trouverez ci-joint une copie reliée du rapport mentionné en titre.

Nous espérons le tout à votre entière satisfaction. Si vous avez des questions ou commentaires concernant ce rapport, ou si vous désirez des copies supplémentaires différentes, n'hésitez pas à communiquer avec nous.

Veuillez agréer, monsieur Rousseau, l'expression de nos sentiments les meilleurs.

Gilles Leroux,
DÉCIBEL CONSULTANTS INC.

PN/mm
p.j.

PROJET DE RECHERCHE
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PROJET DE RECHERCHE
SUR LE BRUIT D'APPAREILS MÉNAGERS
DANS LES IMMEUBLES MULTI-LOGEMENTS

SOMMAIRE

Une étude a été commandée par la Société canadienne d'hypothèques et de logements afin d'évaluer la pertinence, sur le plan de l'insonorisation, de l'installation de matériaux résilients aux interfaces reliant à la structure d'un logement, certains appareils ménagers et sanitaires ainsi que les comptoirs.

Ce projet de recherche a été conjointement réalisé par la firme Décibel Consultants Inc. et le Centre d'étude sur le bâtiment de l'université Concordia.

Les différents tests ont été effectués dans les laboratoires de l'université sur un banc d'essai constitué essentiellement d'un plancher surélevé couvrant une superficie de 2400mm par 3000mm. Le choix du matériaux principal constituant le plancher s'est arrêté sur le bois étant donné son utilisation plus fréquente par l'industrie de la construction au Canada. La composition du plancher a été tiré du code national du bâtiment avec un indice d'affaiblissement sonore ITS de 50, soit le minimum imposé dans la version 1990.

Sur cette plate-forme, les appareils sanitaires et ménagers suivants ont été installés et soumis aux conditions spécifiées:

- machine à laver : cycle normal
- sécheuse : cycle normal
- lave-vaisselle : cycle normal
- bain avec douche : eau coulant de la douche
- toilette : eau coulant d'une hauteur de 1m du sol
- comptoir : source de vibration constante à bande large

Les matériaux résilients qui ont été soumis aux tests sont énumérés ci-dessous; ceux-ci ont été sélectionnés en fonction de leurs disponibilités, leurs coûts ainsi que leurs utilisations actuelles sur le marché.

- coussins de néoprène gaufré, DURO 30; 14mm d'épaisseur
- revêtement de liège; Dodge Cork; 5mm d'épaisseur
- revêtement de caoutchouc recyclé; Everlast; 10mm d'épaisseur
- plancher flottant [i] ; Acousti-mat
- plancher flottant ; Enkasonic
- plancher flottant ; Sonopan

Les principales conclusions qui ont été tirées des tests effectués sont résumées ci-dessous:

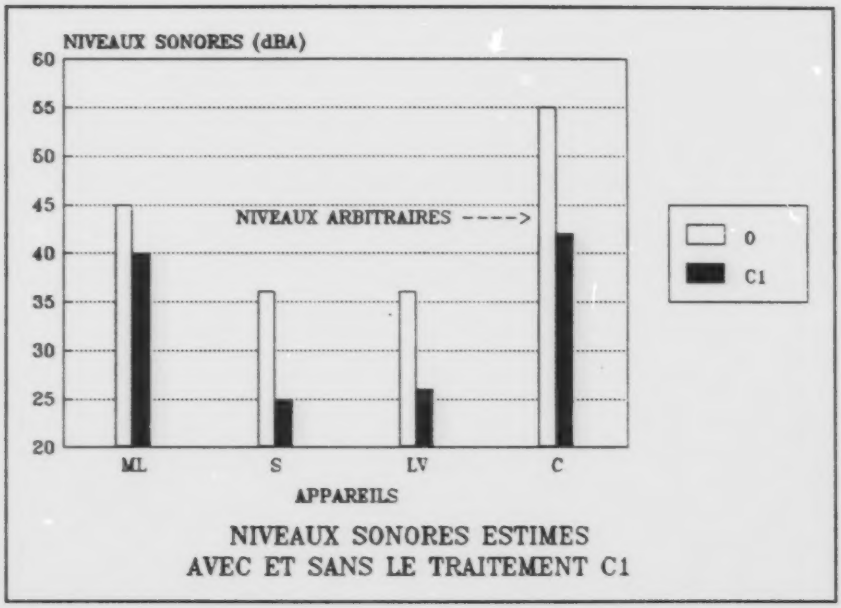
- L'assemblage plancher/plafond utilisé dans la présente étude offre une atténuation des bruits solidiens importantes. Les appareils qui ont été soumis aux tests permettant d'estimer le niveaux sonores dans un espace sous-jacent ont tous produit des niveaux inférieurs ou égaux à 45 dBA, ce qui est la valeur du bruit ambiant moyen typique d'un logement[2].

- Le système plafond/barres résilientes semble posséder une résonnance à la bande de ⅓ d'octave 125 Hz, ce qui coïncide avec une harmonique de la fréquence d'excitation des appareils testés possédant un moteur. Malgré les niveaux sonores relativement faibles qui devraient être transmis à un logement sous-jacent à un assemblage plancher/plafond tel que celui utilisé sur le banc d'essai, la présence d'une tonalité pourrait rendre le bruit transmis potentiellement dérangeant.

---

i *Les planchers flottants avaient une surface de 1000mm par 1000mm et étaient constitués de deux contreplaqués superposés de 19mm installés sur le produit spécifié, le tout sur le plancher de base.*

- Le seul traitement ayant démontré une constance dans sa capacité de réduire la transmission de la vibration à un plancher et la retransmission du bruit est les coussins de néoprène DURO 30 de 14mm d'épaisseur. Les niveaux sonores estimés pour 4 appareils testés (c.f. abréviations à la page ix) sont indiquées à la figure ci-dessous. À noter que ce traitement permet aussi d'éliminer dans la majorité des cas la présence de la tonalité identifiée au paragraphe précédent.



NIVEAUX SONORES ESTIMES
AVEC ET SANS LE TRAITEMENT C1

Il est recommander de mettre en place le traitement consistant en des coussins de néoprène (C_1) dans différents logements avec plusieurs types d'assemblage plancher/plafond ayant des capacités de réduction des bruits solidiens inférieurs à celle du plancher utilisé dans la présente étude, notamment un plancher de béton. L'efficacité du traitement serait alors mesurée dans différentes conditions réelles et la possibilité d'en recommander l'usage de façon généralisée pourrait ainsi être confirmée.

RESEARCH PROJECT ON NOISE FROM HOUSEHOLD APPLIANCES IN MULTY-HOUSING BUILDINGS

SUMMARY

A study was ordered by Canada Mortgage and Housing Corporation to evaluate the pertinence, as far as soundproofing is concerned, of the installation of materials resilient to interfaces linking to the structure of a housing unit, some household and sanitary appliances as well as counters.

This research project was jointly achieved by the firm Décibel Consultants Inc. and the Centre d'étude sur le bâtiment of Concordia University.

Different tests were carried out in the Laboratories of the University on a testing bench made up essentially of a raised floor covering an area of 2400mm by 3000mm. The choice of the main material making up the floor fell on wood given its more frequent use by the construction industry in Canada. The composition of the floor was taken from the National Building Code with a sound transmission class rating STC of 50, that is the minimum imposed in the 1990 version.

On this platform, the following sanitary and household appliances were installed and submitted to specific conditions:

- washing machine : normal cycle
- dryer : normal cycle
- dish washer : normal cycle
- bath with shower : water leaking from the shower
- toilet : water leaking from a height of 1m from the ground
- counter : source of wide range constant vibration

Resilient materials that have been submitted to tests are listed below; these have been selected in accordance with their availability, their costs as well as their present utilizations on the market.

- neoprene wafer cushion, DURO 30; 14mm thick
- cork covering; Dodge Cork; 5mm thick
- recycled rubber covering; Everlast; 10mm thick
- floating floor : Acousti-mat
- floating floor : Enkasonic
- floating floor : Sonopan

---

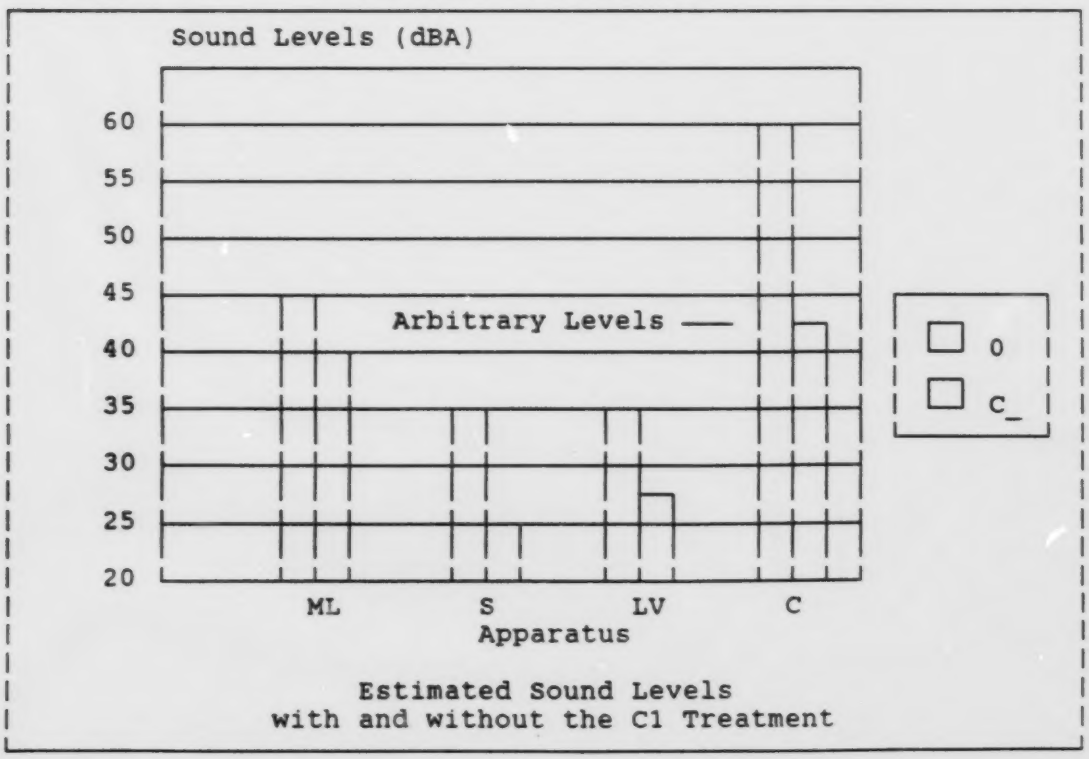
i Floating floors had a 1000mm by 1000mm area and were made up of two superimposed plywoods of 19mm installed on the specified product, the whole on the basic floor.

The main conclusions drawn from the tests that have been carried out are summarized below:

- The floor/ceiling assembly used in the present study offers a softening of major solidborne noises. The appliances that were submitted to the tests making it possible to estimate the sound level in an underlying space have all produced levels lower or equal to 45 dBA, which is the value of the typical average surrounding noise in a housing unit[2].

- The resilient ceiling/bar system seems to have a resonance of 1/3 octave band 125 Hz, which coincides with a harmonic in the stimulus frequency of apparatus tested having a motor. In spite of the relatively weak sound levels that should be sent to an underlying housing unit to a floor/ceiling assembly such as that used on the test bench, the presence of tone could make the noise transmitted potentially disturbing.

- The only treatment having shown a constancy in its capacity to reduce transmission of vibration to a floor and the retransmission of noise is the 14 mm thick DURO 30 neoprene cushion. The sound levels estimated for 4 tested apparatus (c.f. abbreviations on page ix) are indicated on the figure below. To be noted that this treatment also allows eliminating in the majority of cases the presence of tone identified in the preceding paragraph.



Estimated Sound Levels
with and without the C1 Treatment

It is recommended setting up the treatment consisting of neoprene cushions (C_1) in various housing units with several types of floor/ceiling assemblies with capacity to reduce soundborne noises lower than that of the floor used in the present study, particularly a concrete floor. The efficiency of the treatment would then be measured under different actual conditions and the possibility of recommending its use in a generalized way could thus be confirmed.

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Canada

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LISTE DES ABRÉVIATIONS

SCHL : Société canadienne d'hypothèques et de logements

TRAITEMENT:

0 : Test sans traitement

B : Test sans aucun appareil en fonction

C_1 : coussins de néoprène gaufré de 50mm X 50mm, DURO 30; 14mm d'épaisseur, installés sous les points d'appui des appareils

C_2 : revêtement de liège de 1000mm X 1000mm; Dodge Cork; 5mm d'épaisseur

C_3 : revêtement de caoutchouc recyclé de 1000mm X 1000mm; Everlast; 10mm d'épaisseur

PF_1 : plancher flottant de 1000mm X 1000mm ; Acousti-mat

PF_2 : plancher flottant de 1000mm X 1000mm ; Enkasonic

PF_3 : plancher flottant de 1000mm X 1000mm ; Sonopan

APPAREIL:

ML : Machine à laver

S : Sécheuse

LV : Lave-vaisselle

C : Comptoir

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Sound Intensity Measurements - What went wrong!

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ANNEXE D Brochures techniques de certains traitements résilients

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INTRODUCTION

Les personnes demeurant dans des immeubles multi-logements deviennent de plus en plus exigeants en ce qui a trait à l'insonorisation de leurs unités, et plus particulièrement lorsqu'elles en sont propriétaires.

Les méthodes permettant d'atteindre une capacité d'insonorisation aux bruits aériens acceptable sont généralement connues et appliquées.

Cet aspect de l'insonorisation d'un logement n'est toutefois pas complet en soi puisque d'autres sources de bruit peuvent venir perturber la quiétude de logements voisins, notamment les bruits de plomberie, les bruits d'impact et les bruits provenant d'appareils sanitaires ou ménagers.

De meilleures techniques d'isolement acoustique rehausseraient la qualité des habitations à forte et moyenne densité et susciteraient davantage l'intérêt des acquéreurs vis-à-vis ce type de logement.

Les techniques d'installation de la plomberie afin de réduire la transmission du bruit ont fait l'objet d'une étude antérieure de la SCHL [1] et devraient dans l'avenir être appliquées sur une plus grande échelle. D'autre part, un nombre important de constructeurs limitent au minimum l'utilisation de revêtement de plancher dur afin de réduire la transmission de bruits d'impact. Quant au contrôle à la source du bruit d'appareils sanitaires et ménagers, il n'est pas du ressort des constructeurs d'habitations. Restent alors les vibrations se transmettant directement dans les planchers à partir de ces appareils.

La présente étude vise essentiellement à évaluer la pertinence de traitements pour ce dernier aspect.

CHAPITRE 1
DESCRIPTION DE L'ÉTUDE

1.1 OBJECTIF

La présente étude vise essentiellement à quantifier, sur une base comparative, le degré d'insonorisation procuré par différents matériaux résilients, sous forme de coussins ou de plancher flottant, pour certains appareils sanitaires et ménagers ainsi que pour des comptoirs.

1.2 MÉTHODOLOGIE

La méthodologie générale élaborée pour évaluer l'efficacité des différents matériaux anti-vibratiles sélectionnés consistait à modifier l'interface reliant un appareil à un plancher de base et de mesurer l'impact sur le bruit transmis à l'espace sous-jacent par rapport à une situation sans traitement.

Le bruit émit par les appareils listés au tableau 1 et installée sur les matériaux anti-vibratiles indiqués au tableau 2 a fait l'objet de la présente étude. À noter que ces derniers ont été identifiés par des abréviations (c.f. page ix) sur les figures présentées dans ce rapport.

TABLEAU 1
LISTE DES APPAREILS

machine à laver
sécheuse
lave-vaisselle
bain avec douche
toilette
comptoir

TABLEAU 2
LISTE DES MATÉRIAUX ANTI-VIBRATILES

coussins de néoprène gaufré de 50mm X 50mm, DURO 30; 14mm d'épaisseur
revêtement de liège de 1000mm X 1000mm; Dodge Cork; 5mm d'épaisseur
revêtement de caoutchouc recyclé de 1000mm X 1000mm; Everlast; 10mm d'épaisseur
plancher flottant [1]; Acousti-mat
plancher flottant; Enkasonic
plancher flottant; Sonopan

Les brochures techniques de certains produits indiqués au tableau 2 sont présentées à l'annexe D.

Un banc d'essai couvrant une superficie 2400mm par 3000mm a été construit à l'intérieur des laboratoires de l'université Concordia afin de servir de support aux tests. Sa configuration est illustrée à la figure 1 de la page suivante.

La composition de l'assemblage plancher/plafond, indiquée au tableau 3, a été sélectionnée en ayant comme critère un indice d'atténuation des bruits aériens de ITS 50, soit la valeur minimale imposée dans la version de l'année 1990 du code national du bâtiment du Canada.

TABLEAU 3
COMPOSITION DE L'ASSEMBLAGE PLANCHER/PLAFOND

contreplaqué de 11 mm
contreplaqué de 15.5mm
solive de 38mm x 235mm, 400mm entre axes
laine de fibre de verre, 2 x 90mm
profilés métalliques , 200mm entre axes
plaques de plâtre de 15.9mm de type X

1 *Les planchers flottants avaient une surface de 1000mm par 1000mm et étaient constitués de deux contreplaqués superposés de 19mm installés sur le produit spécifié au tableau 2, le tout sur le plancher de base.*

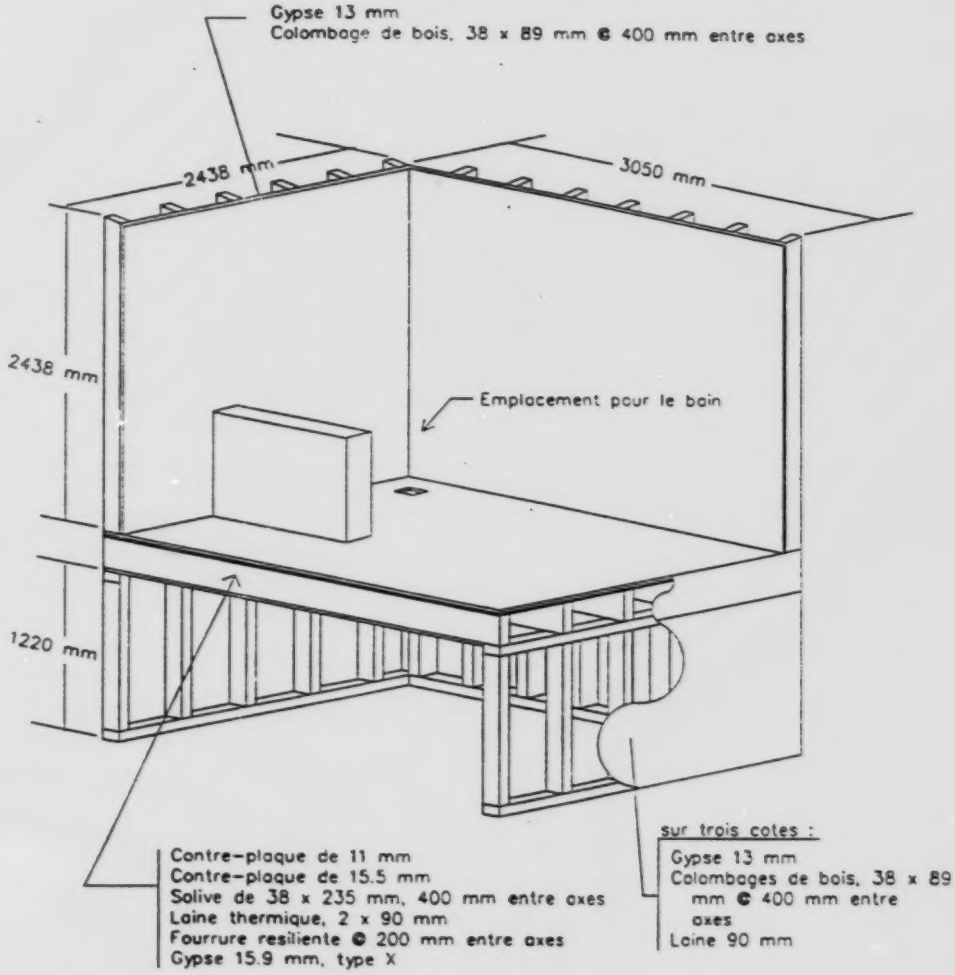

FIGURE 1 - CONFIGURATION DU BANC D'ESSAI

Pour chacun des tests effectués, les relevés suivants ont été effectués, les points de mesure étant identifiés sur les figures 2 et 3 des pages suivantes:

Appareils hors fonction:

- Bruit de fond mesuré à 1m au-dessus du plancher
- Intensité sonore mesurée sur l'axe vertical dans deux directions opposées à une position sous le plancher
- Accélération sur le plancher (ainsi que sur le mur pour le comptoir)

Appareils en fonction:

- Bruit ambiant mesuré à 1m au-dessus du plancher au début et à la fin du test
- Intensité sonore mesurée sur l'axe vertical dans deux directions opposées, à cinq positions sous le plancher (c.f. figure 3)
- Accélération sur le plancher (ainsi que sur le mur pour le comptoir) au début et à la fin du test

Le bruit ambiant et la mesure d'accélération ont été calculés en prenant la moyenne entre les mesures effectuées au début et à la fin des tests.

L'intensité à chacun des points de mesure a été déterminée de la façon suivante, selon que le signe des deux résultats obtenus était identique ou différent.

Signe différent: l'amplitude a été calculée en faisant la moyenne entre les valeurs absolues des deux mesures; le signe était considéré comme exact;

Signe identique: l'amplitude a été calculée en divisant de moitié la différence entre les valeurs absolues des deux mesures; le signe était le même que celui de la mesure ayant l'amplitude la plus élevée.

L'intensité finale est la moyenne des valeurs obtenues aux 5 positions de mesure.

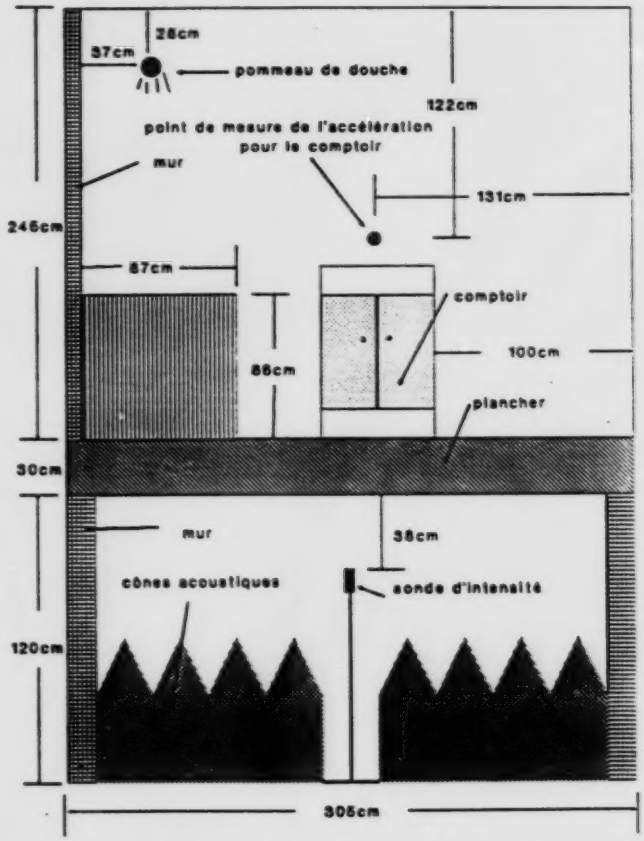

FIGURE 2 - POSITION DES POINTS DE MESURE (vue en élévation)

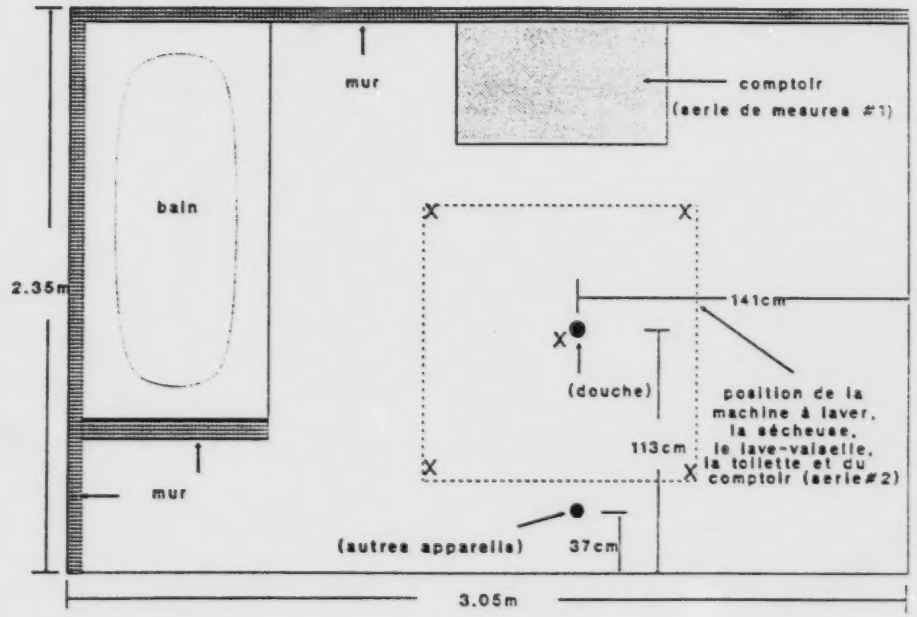

FIGURE 3 - POSITION DES POINTS DE MESURE (vue en plan)

À noter que l'intensité a été mesurée dans deux directions opposées pour annuler l'erreur de phase qui prend des proportions importantes lorsque les mesures sont effectuées dans un milieu contenant des ondes stationnaires (c.f. annexe A).

Toutes les mesures ont été prises en dBA par bande de 1/3 d'octave de 63Hz à 4000Hz. La période d'échantillonnage était de 64 sec.

La liste des tests effectués est présentée au tableau 4:

TABLEAU 4
LISTE DES TESTS (Série 1)

Appareil	Matériaux à tester							
	B	0	C_1	C_2	C_3	PF_1	PF_2	PF_3
Machine à laver	X	X	X	X	X	X	X	X
Sécheuse	X	X	X	X	X	X	X	X
Lave-vaisselle	X	X	X	X	X	X	X	X
Bain avec douche	X	X	X					
Toilette	X	X				X	X	X
Comptoir	X	X	X					

Le paramètre principal avec lequel il était prévu d'évaluer l'efficacité des produits testés était l'intensité sonore mesurée sur un axe perpendiculaire à la surface inférieure de l'assemblage plancher/plafond du banc d'essai.

Suite à la réalisation des premiers tests, l'écoulement de l'énergie sonore dans l'espace sous l'assemblage plancher/plafond, mesuré par l'intensité acoustique, s'est avéré être trop complexe pour pouvoir tirer des conclusions valables en ce qui a trait à l'efficacité des différents traitements considérés.

Les résultats des mesures de vibration ainsi que du bruit ambiant près des appareils en fonction ont toutefois été conservés.

Les modifications indiquées à la figure 4 de la page suivante ont donc été apportées au banc d'essai afin de réduire la transmission du bruit par les voies de flanquement.

Ces travaux n'ont pas entraîné de changements significatifs sur le champs sonore; les hypothèses pouvant expliquer cette situation sont indiquées aux annexes A1, B1 et C1, celles-ci ayant été proposées par le Dr Guy de l'université Concordia.

Un problème additionnel a été identifié à la suite des tests préliminaires, soit le faible rapport signal/bruit. En effet, malgré la présence des voies de flanquement, le niveau sonore sous le plancher n'était pas significativement supérieur au bruit de fond présent dans le laboratoire. Cette situation peut s'expliquer d'une part par la faiblesse du bruit irradié par les appareils testés, et d'autre part par «la trop grande» atténuation des bruits solidiens et aériens procurée par l'assemblage plancher/plafond.

La méthodologie générale des mesures a donc été modifiée et adaptée aux contraintes inhérentes à la configuration du banc d'essai.

L'élément majeur de la méthodologie révisée se situe au niveau du paramètre utilisé pour évaluer l'efficacité des différents matériaux testés. Il a été convenu que le paramètre le plus représentatif de la capacité des matériaux testés à réduire la transmission du bruit par le plancher était le niveau de vibration de la paroi de gypse constituant le plafond.

Puisqu'il le niveau de bruit dans l'espace sous l'assemblage plancher/plafond est directement proportionnel au niveau de vibration du plafond, ce dernier peut être utilisé pour évaluer la réduction sonore procurée par les traitements un par rapport à l'autre.

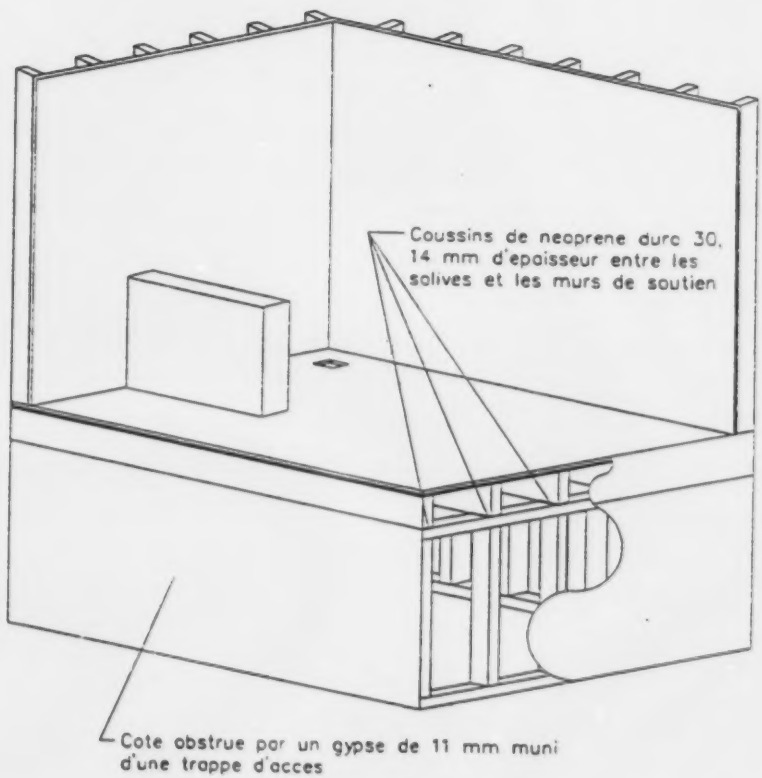

FIGURE 4 - CONFIGURATION DU BANC D'ESSAI MODIFIÉ

Afin d'évaluer sur une base absolue le niveau sonore qui devrait être perçu dans un espace situé sous l'un des appareils testés et fonctionnant sur un assemblage plancher/plafond tel que celui du banc d'essai, un test spécifique a été élaboré afin d'établir la corrélation entre les niveaux de vibration du plafond et le niveau du bruit irradié.

Ce test spécifique a consisté à positionner au centre du plancher une source de bruit et de vibration intense et à bande large installée sous une enceinte en gypse avec coussin de laine de fibre de verre. La vibration a alors été mesurée sur le plafond, ainsi que le niveau de pression sonore dans l'espace sous l'assemblage plancher/plafond.

Étant donné que les voies de flanquement étaient éliminées par l'ajout d'une enceinte autour de la source de bruit, la pression sonore mesurée correspondait uniquement au bruit émanant du plancher. Par calcul, le niveau de pression sonore pour chaque situation a donc été déterminé avec la relation vibration/bruit établit par ce test.

La liste des tests effectués dans la deuxième série est présentée au tableau 5. Cette série s'est limitée au appareils ayant générés les niveaux de vibration les plus élevés tels que mesurés dans la première série de mesures.

TABLEAU 5
LISTE DES TESTS (Série 2)

Appareil	Matériaux à tester							
	B	0	C_1	C_2	C_3	PF_1	PF_2	PF_3
Machine à laver	X	X	X	X	X	X	X	X
Sécheuse	X	X	X	X	X	X	X	X
Lave-vaisselle	X	X	X	X	X	X	X	X
Comptoir	X	X	X	X	X	X	X	X

1.3 INSTRUMENTATION

Les instruments utilisés lors des tests sont schématisés à la figure 5 pour la série 1. En résumé, un analyseur Brüel & Kjaer Type 3360 à été utilisé pour collecter et traiter les données. Celui-ci était contrôlé par deux programmes basés sur un micro ordinateur IBM avec une interface GPIB.

Un sonomètre B&K type 2209 était relié au canal A pour la mesure du bruit ambiant. L'accélération était mesurée par un capteur B&K type 2511 relié au canal B. Une sonde à intensité avec microphones de 12mm était localisée à 375 mm sous le plancher et était raccordée aux canaux A et B.

Chaque instrument a été calibré avant les tests et les corrections nécessaires ont été effectuées au besoin.

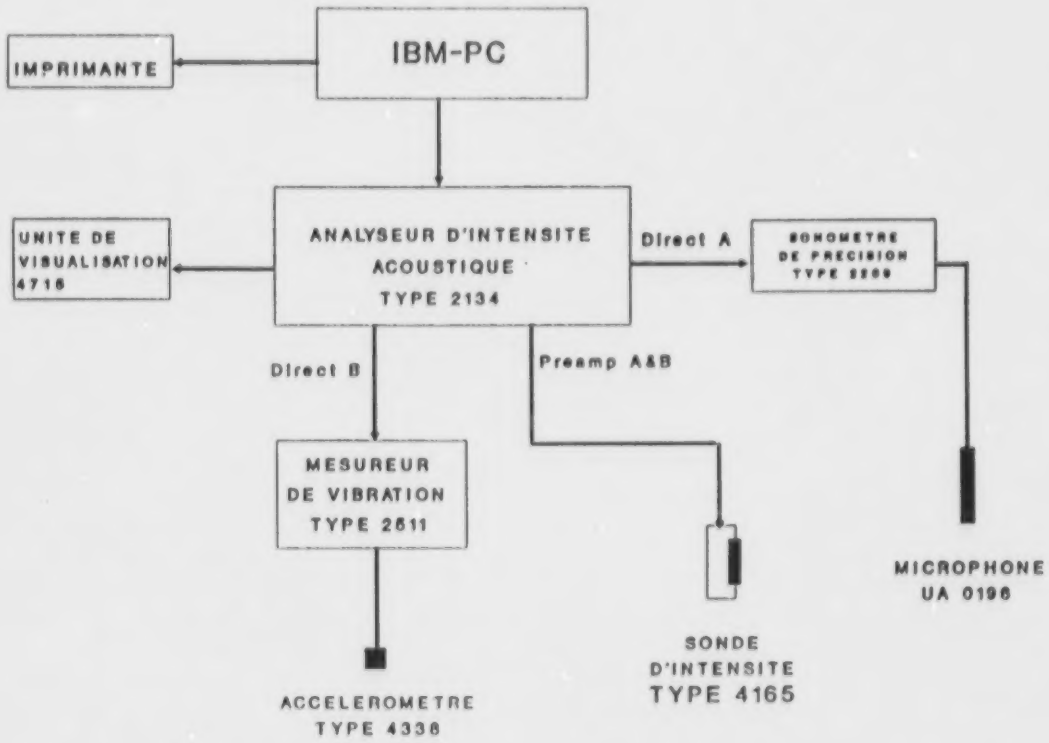

FIGURE 5 - INSTRUMENTS DE LA SÉRIE DE MESURE 1

CHAPITRE 2
RÉSULTATS ET ANALYSES DES MESURES

2.1 SÉRIE DE MESURES # 1

Tel que mentionné précédemment (c.f. chapitre 1), les données qui ont été conservées de la première série de mesures sont les niveaux de vibration mesurés sur le plancher ainsi que les niveaux de bruit mesurés près des appareils en fonction. Les résultats sont présentés à l'annexe E.

À noter que les niveaux de vibration ont été présentés pour les bandes de ⅓ d'octave allant de 63 à 1000 Hz, le montage de l'accéléromètre présentant une résonnance à 1250 Hz.

Les principales conclusions qui peuvent être tirées de ces figures sont présentées aux paragraphes suivants. À noter que les commentaires formulés sur les différents traitements doivent être considérés à titre de référence seulement puisque les relevés effectués lors de la deuxième série de test sont plus susceptibles de donner des informations sur la transmission du bruit vers l'espace sous-jacent à l'assemblage plancher/plafond.

Les figures de la section 2.1 (figures 6 à 8) présentent les différences dans les niveaux globaux de vibration mesurés sur le plancher entre les tests avec et sans traitement. Par conséquent, plus la valeur indiquée est élevée, plus le traitement est efficace.

2.1.1 **Machine à laver** (c.f. figures E1 et E6)

La machine à laver a généré les plus hauts niveaux de vibration du groupe d'appareils testés pour les basses fréquences, plus particulièrement à la bande de ⅓ d'octave 125 Hz.

La mise en place des différents traitements ont procuré les réductions globales de vibration en dBA indiquées à la figure 6.

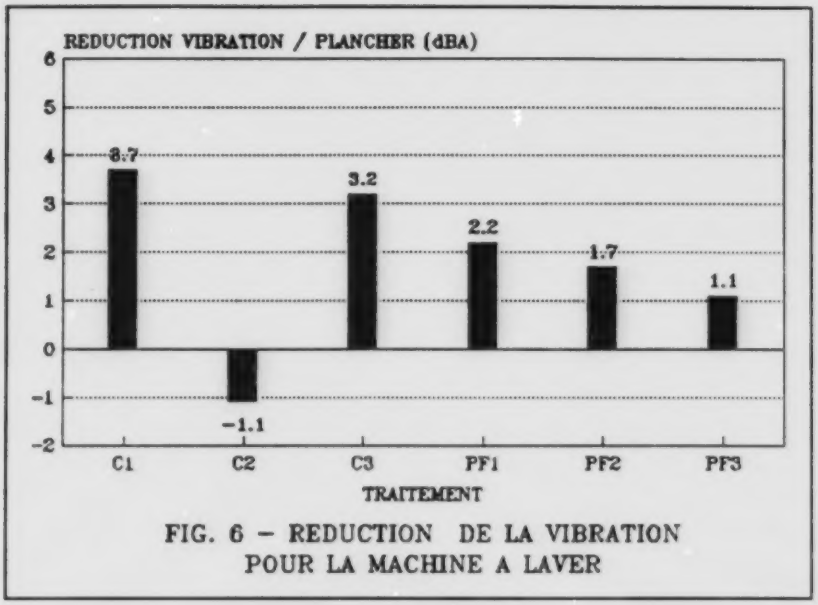

FIG. 6 – REDUCTION DE LA VIBRATION POUR LA MACHINE A LAVER

Les atténuations obtenues sont marginales, les coussins en néoprène (C_1) et le revêtement en caoutchouc recyclé (C_3) ayant obtenus les plus hautes valeurs à près de 3 dBA de réduction.

2.1.2 Sécheuse (c.f. figures E2 et E7)

La sécheuse a généré les plus hauts niveaux de vibration à moyennes et hautes fréquences, ce qui pourrait être attribuable à la présence d'un veston avec boutons métalliques à l'intérieur de celle-ci. À noter que les niveaux sonores indiqués sur la figure E2 doivent être considérés qu'à titre de référence puisque la sortie d'air n'était pas relié à un conduit flexible.

La mise en place du revêtement de caoutchouc recyclé (C_3) a procurée une réduction du niveau global de vibration sur le plancher de plus de 7 dBA.

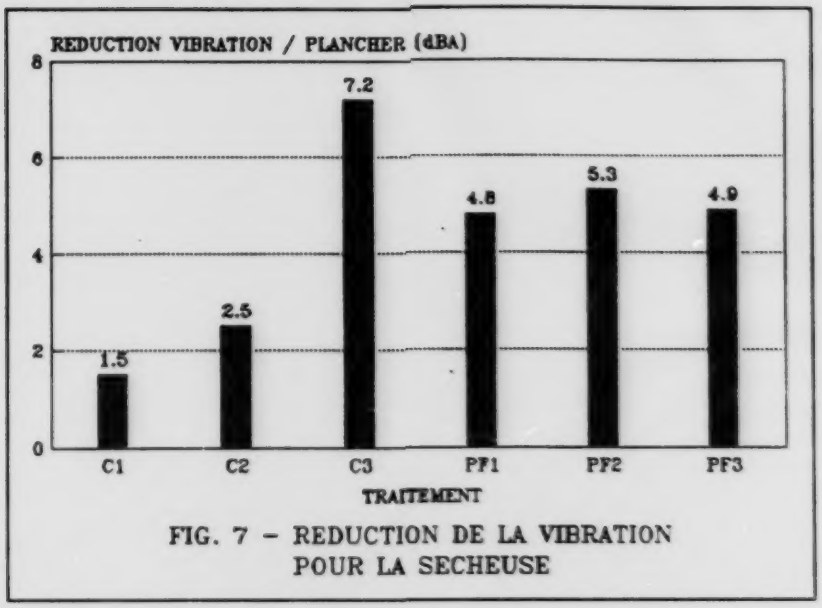

FIG. 7 – REDUCTION DE LA VIBRATION POUR LA SECHEUSE

Les planchers flottants ont pour leur part entraîné des réductions de l'ordre de 5 dBA.

2.1.3 **Lave-vaisselle** (c.f. figures E3 et E8)

Le lave-vaisselle a généré principalement des moyennes et hautes fréquences, sans la présence de tonalité particulière.

Les traitements les plus performants ont été les coussins de néoprène (C_1) et le revêtement de caoutchouc recyclé (C_3).

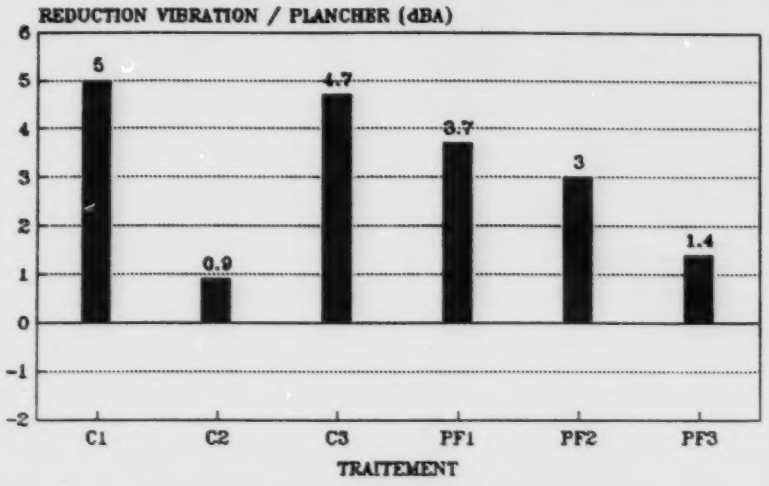

FIG. 8 – REDUCTION DE LA VIBRATION POUR LE LAVE-VAISSELLE

2.1.4 Bain (c.f. figures E4 et E9)

La chute de l'eau dans le bain a généré des vibrations à moyennes et hautes fréquences. La présence de la crête dans les niveaux sonores mesurés provenait du sifflement de la pomme de douche.

La mise en place de néoprène entre le mur et le bain ainsi qu'au niveau des supports sur le plancher n'a procuré qu'une atténuation sur le niveau global de vibration de 2 dBA sur le plancher.

2.1.5 Toilette (c.f. figures E5 et E10)

La chute d'un jet d'eau d'une hauteur de 1m a générée des niveaux de bruit et de vibration important à 400 Hz.

L'installation de la toilette sur les planchers flottants testés a permis d'obtenir des atténuations jusqu'à 13 dBA sur le niveau de vibration mesurés sur le plancher.

2.1.6 Comptoir

Le niveau de vibration générée ne peut être commenté puisque la source de vibration était arbitraire.

L'installation de néoprène entre le comptoir et le mur a occasionné une chute dans le niveau global de vibration de 4 dBA sur le mur, et de 1 dBA sur le plancher, démontrant la contribution de la jonction avec le mur dans la transmission de la vibration vers des espaces sous-jacents par l'entremise du plancher. La pose additionnelle de néoprène entre le comptoir et le plancher a entraîné une diminution de près de 12 dBA sur la vibration mesurée sur le plancher.

2.2 SÉRIE DE MESURES # 2

L'ensemble des résultats de la série de mesures #2 est présentés à l'annexe F. L'analyse de ces figures est traitée dans les paragraphes suivants.

Les figures de la section 2.2 (figures 9 à 12) présentent les niveaux sonores globaux estimés sous l'assemblage plancher/plafond avec et sans traitement. Par conséquent, plus les niveaux indiquées sont élevées, moins le traitement est efficace. La réduction obtenue correspond à la différence entre le niveau estimé pour un traitement (C_1 à PF_3) et le niveau sans traiement (0).

2.2.1 Machine à laver (c.f. figures F1 et F5)

Le fonctionnement de la machine à laver induit au niveau du plafond (gypse sur barres résilientes) des vibrations caractérisées par une crête dans la bande de ⅓ d'octave 125 Hz.

Les niveaux sonores estimés dans l'espace sous l'assemblage plancher plafond du banc d'essai sont indiqués à la figure 9. La mise en place de coussins en néoprène (C_1) a procuré une baisse du niveau sonore de 5 dBA, en plus d'éliminer la crête à 125 Hz.

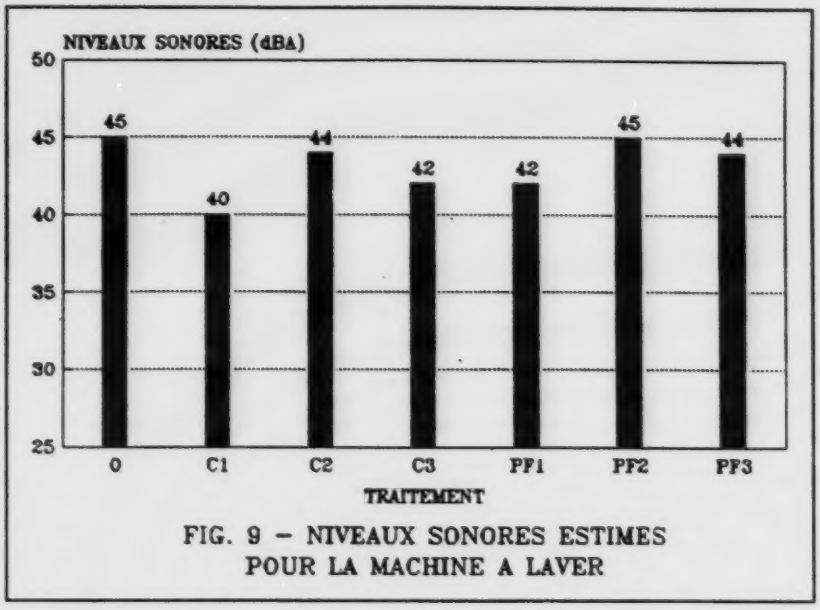

FIG. 9 – NIVEAUX SONORES ESTIMES
POUR LA MACHINE A LAVER

2.2.2 Sécheuse (c.f. figures F2 et F6)

Contrairement à ce qui avait été mesuré sur le plancher dans la première série de mesures, les vibrations générées par le fonctionnement de la sécheuse présentaient une crête à 125 Hz, ce qui pourrait être attribuable à une résonnance du système plafond - barres résilientes excité par le moteur de la sécheuse.

Les niveaux sonores estimés en fonction du traitement implanté sont indiqués à la figure 10.

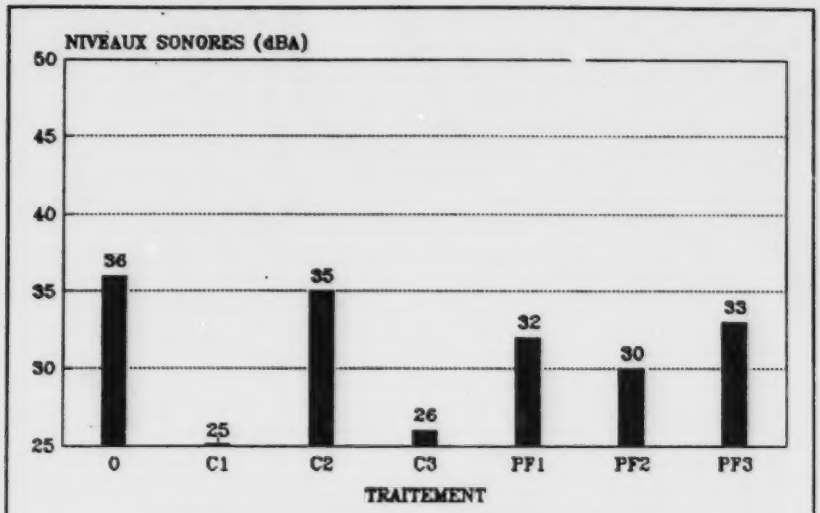

FIG. 10 – NIVEAUX SONORES ESTIMES POUR LA SECHEUSE

La mise en place de coussins de néoprène (C_1) ainsi que du revêtement de caoutchouc recyclé (C_3) a procuré une réduction de l'ordre de 10 dBA du bruit estimés. La crête à 125 Hz n'est par contre éliminée que par les coussins de néoprène.

2.2.3 **Lave-vaisselle** (c.f. figures F3 et F7)

Les vibrations générées par le fonctionnement du lave-vaisselle présentaient aussi une crête à 125 Hz.

La mise en place de coussins de néoprène (C_1) ainsi que du revêtement de caoutchouc recyclé (C_3) a de nouveau procuré les réductions les plus importantes, jusqu'à 10 dBA pour les coussins. La crête a toutefois été atténuée dans une moindre mesure comparativement à ce qui avait été enregistré pour la machine à laver et la sécheuse.

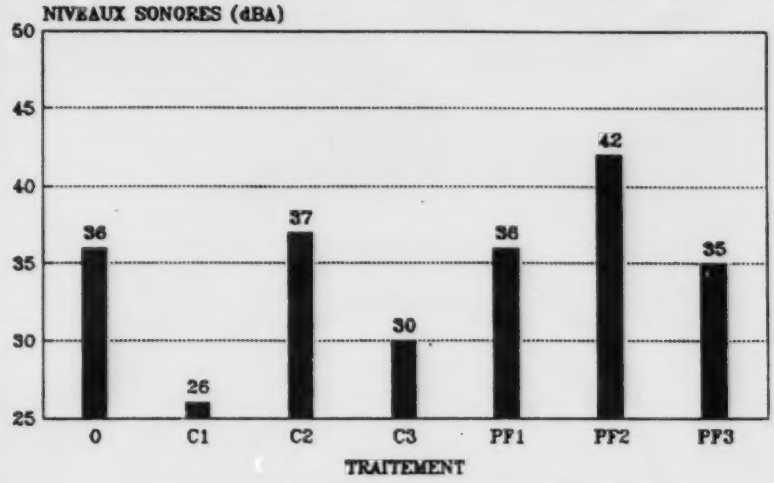

FIG. 11 – NIVEAUX SONORES ESTIMES POUR LE LAVE-VAISSELLE

2.2.4 Comptoir (c.f. figures F4 et F8)

Les niveaux sonores estimés pour les tests avec le comptoir sont présentés à la figure 12. À noter que les niveaux ne sont pas représentatifs d'une situation réelle puisque la source de vibration installée sur le comptoir était arbitraire.

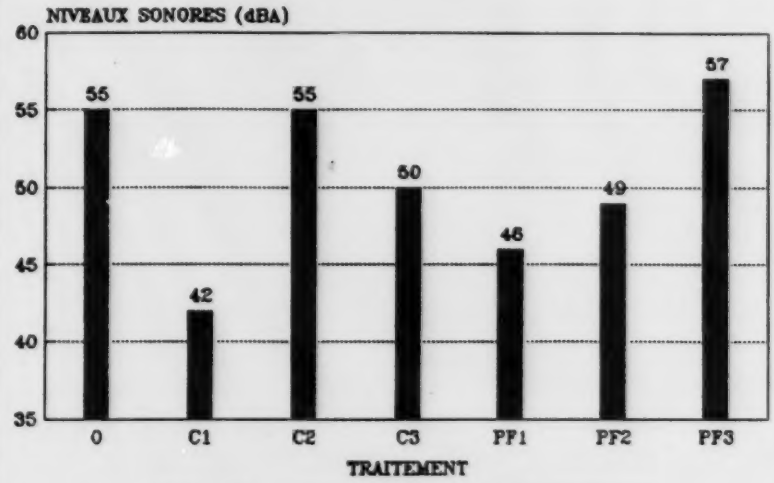

FIG. 12 – NIVEAUX SONORES ESTIMES POUR LE COMPTOIR

Les traitements ayant procuré les réductions les plus importantes sont les coussins de néoprène et le plancher flottant Acousti-mat. Ce dernier n'est toutefois pas particulièrement efficace à basse fréquences

CONCLUSIONS

1 L'assemblage plancher/plafond utilisé dans la présente étude offre une atténuation des bruits solidiens importantes. Les appareils qui ont été soumis aux tests permettant d'estimer le niveaux sonores dans un espace sous-jacent ont tous produit des niveaux inférieurs ou égaux à 45 dBA, ce qui est la valeur du bruit ambiant moyen typique d'un logement[2].

2 Le système plafond/barres résilientes semble posséder une résonnance à la bande de ⅓ d'octave 125 Hz, ce qui coïncide avec une harmonique de la fréquence d'excitation des appareils testés possédant un moteur. Malgré les niveaux sonores relativement faibles qui devraient être transmis à un logement sous-jacent à un assemblage plancher/plafond tel que celui utilisé sur le banc d'essai, la présence d'une tonalité pourrait rendre le bruit transmis potentiellement dérangeant.

3 Le seul traitement ayant démontré une constance dans sa capacité de réduire la transmission de la vibration à un plancher et la retransmission du bruit est l'installation sous les pattes des appareils de coussins de néoprène DURO 30 de 14mm d'épaisseur. Ce traitement permet d'éliminer dans la majorité des cas la présence de la tonalité.

RECOMMANDATIONS

Il est recommandé de mettre en place le traitement consistant en des coussins de néoprène (C_1) dans différents logements avec plusieurs types d'assemblage plancher/plafond ayant des capacités de réduction des bruits solidiens inférieurs à celle du plancher utilisé dans la présente étude, notamment un plancher de béton. L'efficacité du traitement serait alors mesurée dans différentes conditions réelles et la possibilité d'en recommander l'usage de façon généralisée pourrait ainsi être confirmée.

Martin Meunier, ing.
Pointe-Claire
Mars 1992

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2. BRADLEY, J.S., «Acoustical measurements in some Canadian homes», National Research Council

ANNEXE A

Domestic Appliance Vibration Isolation Project: Sound Intensity Measurements - What went wrong!

Appendix A

Domestic Appliance Vibration Isolation Project:

Sound Intensity Measurements

—— What Went Wrong!!

1. Introduction

The Domestic Appliance Vibration Isolation Project in collaboration with Decibel Consultants was initially designed to make full use of the relatively new Sound intensity measurement procedure.

The objectives were of a direct nature, namely, to construct a typical kitchen floor assembly, operate typical domestic appliances upon it with and without a series of vibration isolation mounts, and determine the acoustic energy transmitted to a lower level via the floor thus ranking the various isolation procedures. The floor construction, domestic appliances and vibration isolation procedures are discussed in the main report.

The test floor assembly is shown in Figure A1, and it can be seen that conventional sound pressure measurement procedures would not be sufficient to determine transmitted acoustic energies because of obvious flanking paths. The sound intensity technique was employed to resolve this problem because of its ability to sense vector energy flow - hence the required energies from the ceiling(beneath the test floor) could be distinguished from side wall flanking energies.

In this project, the sound intensity measurement technique did not yield the required data at and over a critical low frequency range(63Hz to 250Hz). This appendix is written to examine the reasons why and contribute to our knowledge stock in the matter of sound intensity usage.

2. Sound Intensity Measurement Procedure

The present test series requires measurements in third octave bands from 63Hz upwards for all measurands, pressure, intensity, velocity and acceleration. Intensity measurements at lower frequencies require careful attention to avoid inherent error problems(finite difference approximation error) which it is now known(see Appendix B) are exacerbated in the presence of standing waves; in the present test circumstance it was anticipated that standing waves would arise at low frequencies in the lower floor cavity despite the presence of absorption materials.

Two measurement procedures were employed to resolve these problems:

a) Probe reversal;
b) Probe scanning with increased microphone spacing.

a) Probe Reversal

Probe reversal is a technique designed to remove channel phase difference errors by measuring with the probe in one direction, then with the probe reversed through 180°, and processing the two sets of data.

Examining the available literature(see Appendix B), it was clear that an adequate processing formulation for measurements within standing waves had not yet been developed and an auxiliary test series was initiated to remedy this fact.

The auxiliary test series is presented in Appendix B of this report and a new correction formulation and reversal procedure is determined to be accurate even in most adverse standing wave circumstances.

The probe reversal procedure was implemented in the present test series by construction of a special probe stand. The probe holder was building floor mounted and positioned the probe approximately 15cm underneath the lower ceiling of the test rig. A single axis, probe arm allowed reversal in the vertical direction upon rotation through 180°. In these measurements a 12mm spacer was used.

In the appliance test series, a typical intensity result determined as an average of five point measurements evenly distributed about the centre section of the ceiling, over a four foot square area, is shown in Figure A2. In the low frequency range negative intensities are evident, and indicate a power flow into the ceiling as opposed to determining a power flow out, which was expected from the appliance caused vibration.

Whilst different appliances and/or vibration isolation treatments caused differing results, negative energy flow was still evident at one or more frequencies in the low frequency range of intensity; in consequence the results did not allow assessment of vibration isolation efficacy.

Two test details could explain the unexpected result:

i) Very high side wall flanking;
ii) Inadequate point sampling over the whole ceiling surface.

As a partial remedy to high side wall flanking, the test rig was modified by cutting all direct structural connections between

the test floor and its supporting side wall structure, and then placing vibration isolation pads between them.

The question of inadequate point sampling was addressed by employing a total ceiling surface scan technique.

b) The Scan Technique

Intensity scanning is a popular method of surveying energy from a test surface in that an automatic integration of total surface result is obtained. At the time of writing no standard test procedure is available in North America, however, a procedure has been introduced in the Scandinavian countries and is referred to as 'The Nord Test Method', a copy of relevant portions are appended as Appendix C of this report.

The Nord test procedure as described in Appendix C, and employing a 50mm probe spacer, was used to monitor the transmitted intensity over the full ceiling surface at a distance of 10cm.

A typical result was similar to Figure A2 particularly with respect to negative power flow at about 125Hz. In consequence this test procedure also could not be used to assess vibration efficacy.

3. Why?

In the initial(probe reversal) test series it was not considered necessary to monitor the vibration of the resiliently mounted ceiling of the test floor assembly as intensity measurement was to indicate transmitted energies. A floor mounted accelerometer was monitored and a typical spectrum similar to that shown in Figure A3 was found; of particular note is that no significant reading or response compared to other frequencies may be ascribed to the frequency regions about 125Hz.

In the second(probe scanning) test series, an accelerometer was mounted at the ceiling centre and monitored as part of the data acquisition sequence. A typical result is shown in Figure A3. Clearly a significant resonance exists at or about 125Hz; since this response is not evident at the floor it is apparent that a ceiling resonance exists.

Both intensity measurement techniques support the fact of an energy flow into the ceiling at or about 125Hz, it therefore is evident that the resilient furring in combination with the ceiling mass is acting as a resonant panel absorber. Under these circumstance energy from flanking paths is being absorbed by the ceiling and positive energy flows can not be sensed. In brief, the floor is too good in relation to the source strength and flanking paths, and also acts as a very efficient absorber from the underside direction.

Compounding these observations are resonance predictions for the isolation pads, see Table A1, which indicate appliance/pad combination resonance frequencies throughout the low frequency range of interest encompassing also the ceiling resonance frequency.

4. Conclusion

In conclusion, the intensity measurements were correctly indicating the power flows but by unforeseeable accident of ceiling design, compounded by the characteristics of some vibration isolation systems, the power flow measurements do not allow one to conclude domestic appliance vibration isolation efficacy. Fortunately, the ceiling/floor vibration measurements do allow useful conclusions to be drawn.

Isolator		C1	C2	C3	C4	PF1	PF2	PF3
Stiffness Constant, K Kg/m per m^2		1.77E7	1.10E8	8.80E7	1.20E8	1.18E6	1.42 E6	8.91 E6
Support Area, A m^2		.0224	.00776	.00776	.00776	.6561	.6561	.6561
Weight W,Kg	Appliance	Isolator Resonant Frequency, Fn, Hz						
97.0	Washer	31.9	46.8	41.8	48.8	42.3	46.4	116.1
48.6	Dryer	45.0	66.1	59.1	69.0	57.0	62.5	156.5
74.7	Dish Washer	36.3	53.3	47.7	55.7	47.5	52.1	130.4
42.8	Toilet	48.0	70.4	63.0	73.5	60.0	65.8	164.8
57.1	Counter	41.5	60.9	54.5	63.7	53.3	58.4	146.4
-	Bath							
10.7	Platform for PF1, PF2, PF3							

Tale A1 : Predicted Resonance Frequencies for isolators and appliance combinations.

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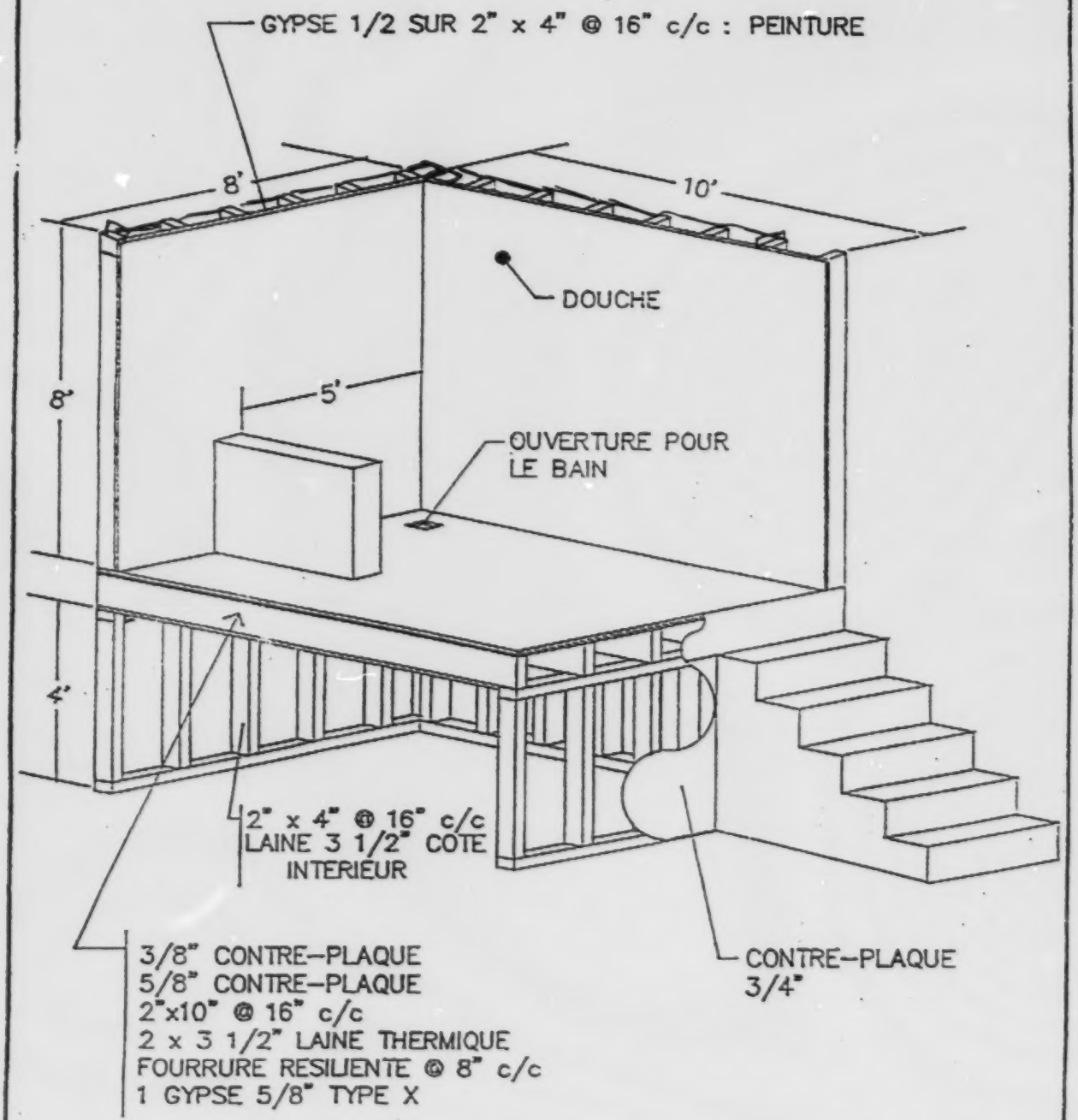

Figure A1 : BANC D'ESSAIS – PROJET SCHL

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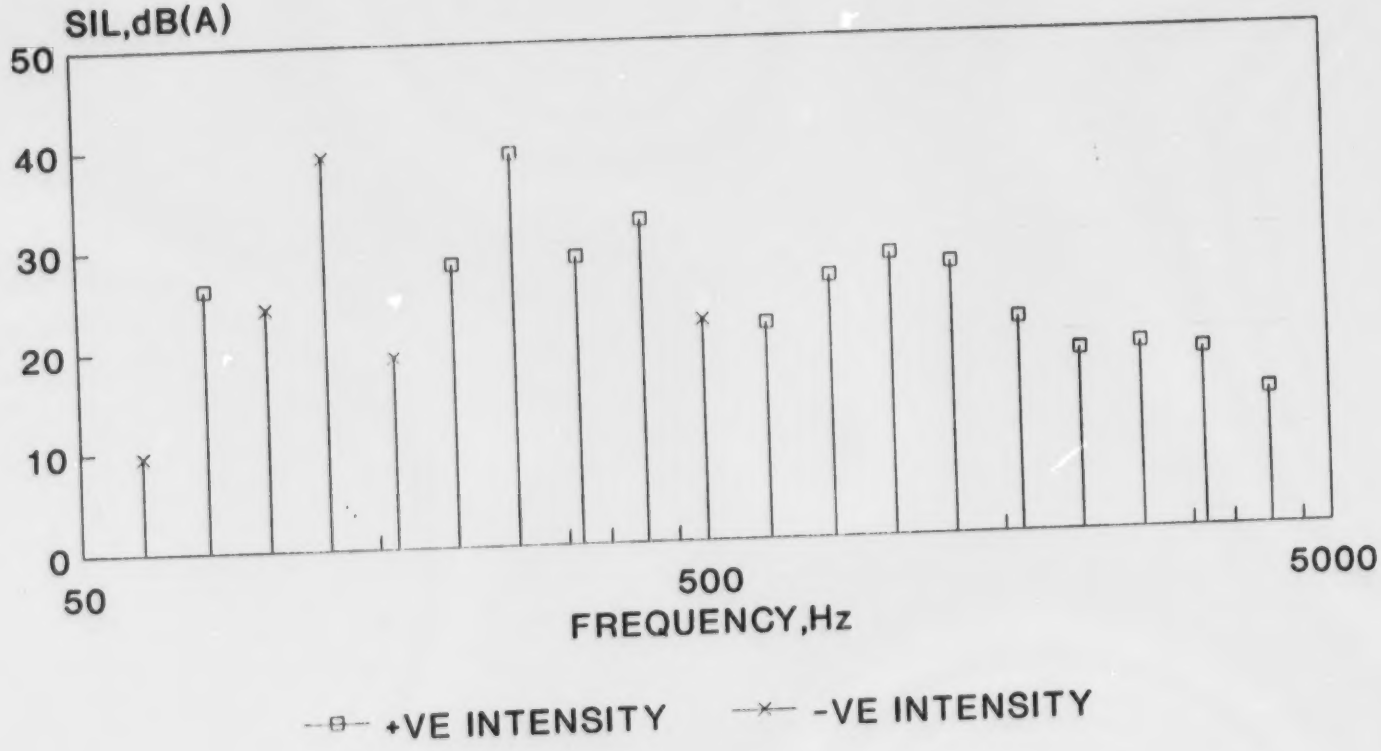

Figure A2: SOUND INTENSITY LEVEL WITH DAMPING PF3 FOR WASHER TEST, LV2/PF3. (PROBE REVERSAL)

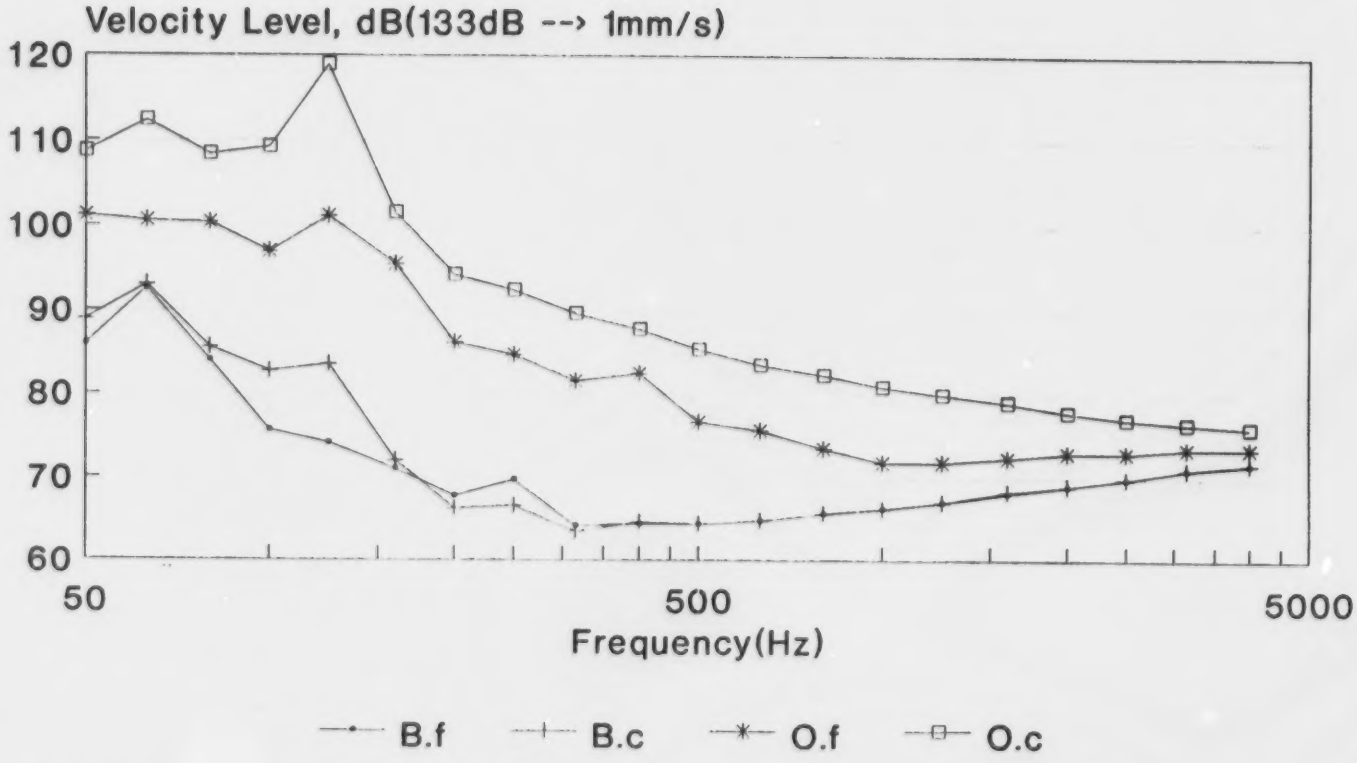

Figure A3:Background(B) and Operation(O)
Velocity Levels of the Washer with
Treatment PF3. Floor(f) and Ceiling(c)

ANNEXE B

True Intensity Assessment Employing Probe Reversal

APPENDIX B

TRUE INTENSITY ASSESSMENT EMPLOYING PROBE REVERSAL

1. INTRODUCTION

When a pressure-pressure probe system is employed to measure intensity an assessment is made of the acoustic particle velocity via a finite difference approximation to the local spatial gradient of sound pressure; this in turn requires that the instrumentation (probe plus processor) be capable of detecting the phase difference between the two microphones of the probe.

Problems of accurate intensity measurement will arise when the phase difference between microphones resulting from the acoustic field are similar to or less than the system channel phase errors. This circumstance can arise even for a well phase matched system is highly reactive fields as might be encountered during a sound power assessment within a reverberation chamber, or, a surface intensity measurement within an unfurnished reception room undertaken to establish a walls' transmission loss.

Channel phase mismatch errors may be compensated for by analytical or computational procedures when a Fast Fourier transfer based system is employed [1,2]; in the case of real time analysis or FFT based systems - "The effect of phase mismatch may effectively be eliminated by taking half the difference (in linear units) between the signed intensities measured (a) with the probe in any position and orientation, and (b) after rotation by 180° about the phase of symmetry (probe reversal)" [3].

It will later be shown that the 'half difference' referred to above requires additional modification, however the probe reversal principal having been stated, there is a dearth of data supporting employment of the technique. By way of testing the procedures efficacy in association with a simple formulation which also accommodates the finite difference approximation error [6] this work presents the results of some probe reversal measurements for different frequencies and probe spacing. In addition a range of ratios between field phase and channel phase error are also investigated including extreme circumstances when the measured intensity does not change sign upon probe reversal.

2. CORRECTION FORMULATION

for sinusoidal signals, the time average value of sound intensity when measured by a pressure-pressure probe may be written as [5]:

$$I = \frac{P_1 P_2 \sin(\phi)}{\omega \rho \, \Delta r_o} \qquad (1)$$

where P_1 and P_2 are the rms values of the sinusoidal pressure signal at microphones 1 and 2 respectively

ϕ is the phase angle between the pressure signals

ϖ the angular frequency

ρ is the density

and Δr_o the microphone spacing

For on axis free field measurements, equation (1) can be processed to yield [6]:

where I_m is the measured intensity

$$I_m = I_T \cdot \frac{\sin(k\Delta r_o)}{k\Delta r_o} \qquad (2)$$

I_T is the true intensity

k is the wave number

and $\frac{\sin(k\Delta r_o)}{k\Delta r_o}$ is a finite difference error term

If a channel phase mismatch error ($\pm\theta$) is now introduced then:-

$$I_m = I_T \cdot \varepsilon \qquad (3)$$

where ε is a modifying multiple to the true intensity involving both finite difference and channel phase error elements and has the general form:

$$\varepsilon = \frac{\sin(k\Delta r_o)}{k\Delta r_o} \cdot \cos(\theta) + \sin(\theta) \cdot C \qquad (4)$$

For on axis measurements within planar standing waves, ε may be written as [4]:where

$$C = \frac{1}{2Rk\Delta r_o}\left[(R^2+1)\cos(k\Delta r_o) + (R^2-1)\cos(2kx)\right] \qquad (5)$$

R is the standing wave ratio (linear)

and x is the measurement position such that cos (2kx) = -1 for measurements at a pressure minimum and cos (2kx) = 1 for measurements at a pressure maximum.

In a free field measurement, R = 1,

$$C = \frac{\cos(k\Delta r_o)}{k\Delta r_o}$$

and equation (4) reduces to the well known form [6]

where θ may be + ve or - ve.

$$\varepsilon = \frac{\sin\,(k\Delta r_o + \theta)}{(k\Delta r_o)} \tag{6}$$

By making on axis probe reversal measurements the true intensity direction and the channel phase difference error is reversed and their respective formulations may be written from equations (3), (4), and (5) as:

$$Im_1 = I_T \left\{ \frac{\sin\,(k\Delta r_o)}{k\Delta r_o} \,.\, \cos(\theta) + \sin(\theta)\,.\,C \right\} \tag{7}$$

$$Im_2 = -I_T \left\{ \frac{\sin(k\Delta r_o)}{k\Delta r_o} \,.\, \cos(\theta) - \sin(\theta)\,.\,C \right\} \tag{8}$$

where Im_1 and Im_2 are respectively the signed measured intensities before and after probe reversal.

Taking the difference between equations (7) and (8), it now follows that:

$$I_T = \frac{Im_1 - Im_2}{2\,\dfrac{\sin(k\Delta r_o)}{k\Delta r_o} \,.\, \overline{\cos\theta}} \tag{9}$$

It may be seen from the denominator of equation (9) that the probe reversal principal as stated in reference [3] (referred to in the introduction) requires qualification in that a correction other than a half difference between signed intensities may be required; this correction does however reduce to one half for small angles $k\Delta r_o \rightarrow 0$ and $\theta \rightarrow 0$.

With the exceptions of residual intensity measurement (that is measurements within a pressure

coupler at nominal zero intensity) or zero channel phase difference, the unsigned measured intensities cannot have equal magnitude. Equation (9) may now be expressed in terms of measured logarithmic values as:

$$IL_T = sgn\,(IL_{max})10\log_{10}\left|\frac{sgn(IL_{max}).10^{|IL_{max}|/10} - sgn(IL_{min})\,.\,10^{|IL_{min}|/10}}{2.\dfrac{\sin(k\Delta r_o)}{k\Delta r_o}\,.\,\cos\theta}\right| \qquad (10)$$

where |ILmax| is the unsigned maximum of the measured intensity level

|ILmin| is the unsigned minimum of the measured intensity level

sgn ( ) refers to the sensed sign (+ or -) of the bracketed intensity level, and the argument of the logarithmic evaluation is taken to be an absolute value.

It should be noted that IL_{max} and IL_{min} will have the same sign when the magnitude of the second term C.sinθ within the brackets of equation (7) and (8) is greatest. This circumstance typically arises when C > 1, which may be seen from equation (5) may occur with high standing wave ratios together with locations where the field phase is minimal (at or about a pressure maximum); when this occurs the direction of the true intensity is the direction indicated when measuring the highest intensity level, IL_{max}.

3. MEASUREMENT PROCEDURE

Measurements were undertaken within a five meter long standing wave tube of square cross section, twenty four by twenty four centimetres, shown diagrammatically in Figure 1.

The operable frequency range is nominally 50 Hz to 630 Hz with the lower frequency limit

chosen to avoid pressure maxima sensing at the termination; in the present test series all intensity measurements are taken at or about the pressure maximum approximately $\lambda/2$ from the termination with the exception of 31.5Hz which are taken close to the termination; these locations ensure the greatest phase difference induced error.

Two ¼" B&K microphones, type 4135 are employed in a face to face configuration as shown in Figure 3, in this way physical probe differences upon reversal were minimized. The microphone assembly was mounted on a carriage of small cross section and could be traversed to any position along the longitudinal axis of the tube whilst maintaining the probe at the centre of the tube cross section, see Figure 1.

Precise probe reversal was achieved by manually reversing the probe assembly about a vertical axis extending from the center of the microphone spacer; care was also taken to ensure that microphone cartridge vent ports presented the same aspect to the axis of propagation upon probe reversal.

Pressure measurements to establish the standing wave ratio were taken from one microphone of the pair; when a pressure maximum was established, the probe carriage was maneuvered so that both microphones of the pair displayed similar pressure readings with each microphone located on either side of the maximum. One exception to this procedure was with respect to measurements at the 31.5Hz pressure maximum; these were assumed given by the nearest microphone to the termination when the carriage was at extreme travel; the nearest microphone was then approximately twenty centimetres from the termination.

Measurements were undertaken at discrete frequencies although a third octave band analyzer and intensity processor B & K type 2134 was employed; for each measurement an averaging time not less than T = 400/B seconds was employed, where B is the third octave band width.

Five frequencies, 500 Hz, 250 Hz, 125 Hz, 63 Hz and 31.5 Hz were tested, each in association with a 6 mm and a 12 mm spacer. In addition a nominally hard reflecting surface and a ten centimetre thick acoustic absorbent foam lined termination was employed; in this way both lower and high standing wave ratios were established over most of the frequency's range.

The residual pressure-intensity index for the instrument was measured for each discrete test frequency by employing a pressure cavity fitted to the end of a one inch diameter standing wave tube of the B & K apparatus type; as described in reference [7], these results are displayed in Table 1 and are referenced to a probe spacing of 12 millimetres.

4. THE RESULTS

The net propagating sound intensity of the standing wave was established from a measurement of the pressure maximum and minimum via the relationship:

$$I = \frac{p\,\mathrm{max} \cdot p\,\mathrm{min}}{\rho c} \qquad (11)$$

where p max is the maximum pressure (rms)

p min is the minimum pressure (rms)

ρ the density of air

c the velocity of sound

In all cases, the intensity established via equation (11) before and after probe reversal did not differ by more than 0.5 dB, more typically 0.2 to 0.3 dB. The average of equation (11) applied before and after probe reversal is referred to as IL_p avge in Table 2.

Intensity level measurements at or about the pressure maximum are shown as $IL_{max\,1}$ and IL_{max2} within Table 2 where $ILmax_1$ is recorded before and $ILmax_2$ after probe reversal. Processing of these values in accordance with equation (10) are shown as IL_{max} avge in Table 2.

The pressure intensity index (PII) is often employed [9] as an indicator of measurement circumstance, the higher its value in relation to the Residual Pressure Intensity Index the greater is the measurement error. For all measurements at or about a pressure maximum PII was positive but differed dependent upon the intensity level indicated for a given probe orientation, typically it was close to R(dB)/2.

5. DISCUSSION

Equation (4) details an error term expressed as a multiple to the true intensity with respect to measurements within a planar standing wave.

In the absence of probe or instrument sensitivity limitations, measurements at or about a pressure maximum will lead to greatest channel phase error induced errors of measurement, with higher errors occurring at high standing wave ratios.

The measured results $ILmax_1$ and $ILmax_2$ clearly exhibit this trend when compared to the true intensity ILp_{avge} and it can also be seen that high standing wave ratio circumstances (> 45dB in

the present measurements) generally cause an absence of sign reversal for the measured intensity upon probe reversal.

The corrected probe reversal measurements in accordance with equation (10) are shown as $ILmax_{avge}$ in Table 2.

Compared to the presumed correct intensity ILp_{avge}, they can be seen to display good agreement.

The instrument (probe + processor) employed in the present measurements qualifies as a general use class II measurement system when tested in accordance with IEC draft standard 1043 [8]. The draft standard stipulates a standing wave performance test whereby a precision class I instruments should not exhibit a difference greater than ± 1.5 dB for intensity measurements along the axis of a wave of standing wave ratio 24 dB at a frequency in the range 125 Hz to 400 Hz (lowest frequency chosen as specified for use); with the exception of 250 Hz in the case of the 12 mm spacer (R=53.6) and 125 Hz in the case of the 6 mm spacer (R=50.4), this tolerance is met despite the significant increase in standing wave ratio and the fact that the standard test circumstance suggest employment of a probe spacing greater than 25 mm (typically 50 mm).

At lower frequencies (63 Hz & 31.5 Hz) an assessment of equation (10) efficacy may be made by comparing results against the free field predictions of equation (4) for a class I probe having a maximum instrument channel error phase difference of 0.09° (the draft standard [8] has a lower frequency limit of 50 Hz but the channel error phase difference implied from pressure-residual intensity requirements is presumed here to extend down to 31.5 Hz).

Figure (3) displays the free field predictions of equation (4) at low frequencies ($\theta = \pm 0.09°$) and the high standing wave low frequency corrected results (63 & 31.5 Hz) of Table 2, compare favourably with them despite the dramatic difference in field circumstances, (R = 0 dB compared to R > 45 dB).

The lower frequency limit for free field measurements employing 12 mm or 6 mm probe spacing is advised by a manufactures (Bruel & Kjaer) to be 125 Hz. The probe reversal corrected result at 63 Hz and standing wave ratio R < 30 dB (in the present measurements) yields an error difference of 0.6 dB and 0.3 dB respectively which is well within the earlier described standing wave test (requirement ±1.5 dB for class I probe at 125 Hz with R = 24 dB). Whilst modestly higher errors are evident at 31.5 Hz, +2.9 dB and 2.4 dB for the 12 and 6 mm probe spacers respectively with R > 45 dB, there are grounds to suppose that these errors will be decreased if a lower standing wave ratio (say < 30 dB) had existed. One may conclude that the frequency range of probe/spacer application may usefully be decreased by employing the probe reversal correction procedure.

CONCLUSIONS

Probe reversal measurements can be used to achieve relatively high accuracy in field circumstances which would normally dictate greater error both in magnitude and directional indications.

A class II probe can yield results equal or better than class I probe requirements when employing the probe reversal technique although great care must be exercised in maintenance of the probes

acoustic centre.

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8. International Electrotechnical Commissions IEC 1043 (Draft) "Instruments for the Measurement of Sound Intensity - Instruments which Measure Sound Intensity with Pairs of Pressure Sensing Microphones" Draft Standard 1991.

9. International Organisation for Standardization (ISO) 9614 "Determination of the Sound Power Levels of Noise Sources Using Sound Intensity Measurements at Discrete Points", ISO/DIS 9614-1, 1989.

FREQUENCY	31.5	63	125	250	500
PRII (dB)	0.7	9.7	10.5	14.1	11.9

Table 1: Pressure Residual Intensity Index (dB) at Discrete Test Frequencies for the Intensity Probe with 12 millimetre spaces.

Frequency Hz	Δr mm	R dB	$ILmax_1$ dB	$ILmax_2$ dB	ILp_{avge} dB	$ILmax_{avge}$ dB
500	12	53.4	-74.0	-76.0	67.8	68.7
	6	48.8	57.9	-61.4	58.6	60.0
	12	10.7	84.9	-84.7	84.6	84.8
	6	11.9	84.2	-84.8	84.0	84.5
250	12	56.6	-82.4	-83.7	72.7	74.8
	6	51.9	-76.0	-76.5	63.2	63.9
	12	6.0	82.8	-82.1	82.3	82.5
	6	6.1	86.6	-86.1	85.9	86.4
125	12	52.2	-85.3	-85.9	74.1	74.0
	6	50.4	-73.5	-78.6	69.2	74.0
	12	20.0	80.6	-80.0	80.3	80.3
	6	19.2	85.7	-86.7	85.6	86.2
63	12	49.0	81.5	80.7	69.5	70.7
	6	47.6	85.0	84.2	69.6	74.2
	12	26.7	84.4	73.3	80.4	81.0
	6	27.0	88.3	79.8	84.3	84.6
31.5	12	45.7	82.4	81.5	69.2	72.1
	6	45.4	82.8	82.0	69.6	72.0

TABLE 2: Test Results for Probe Reversal Measurements and Corrected Values in Accordance with Equation (10).

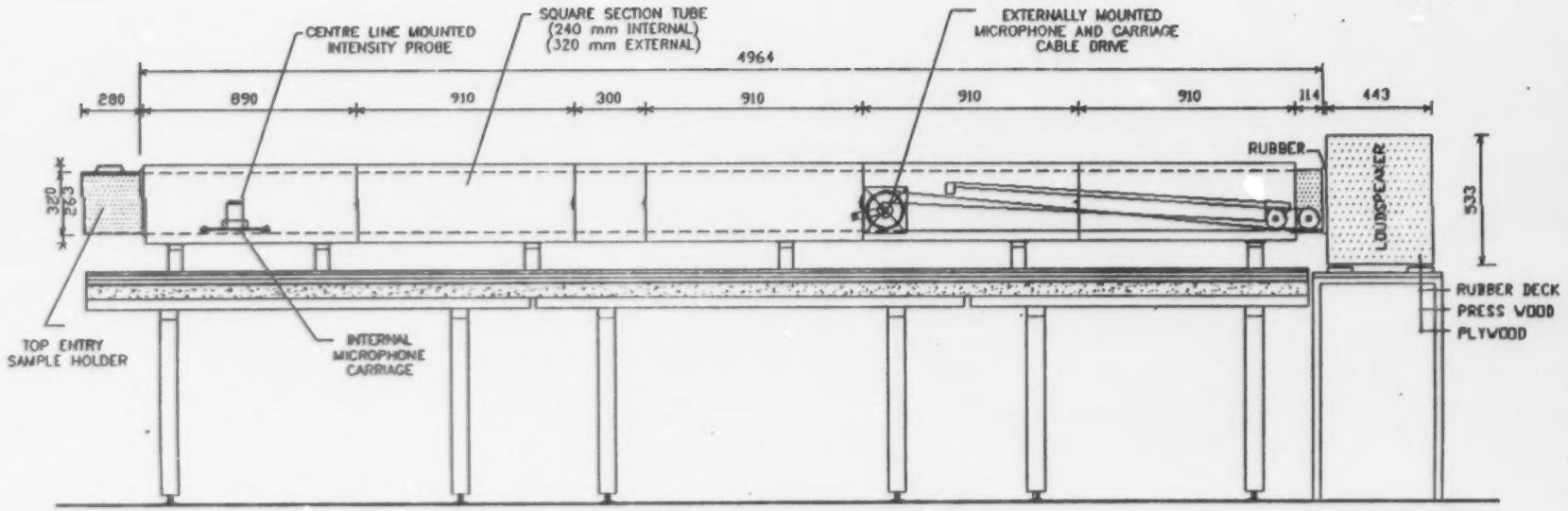


FIG.(B1) CBS LOW FREQUENCY STANDING WAVE TUBE

(ALL DIMENSIONS IN MILLIMETRES)

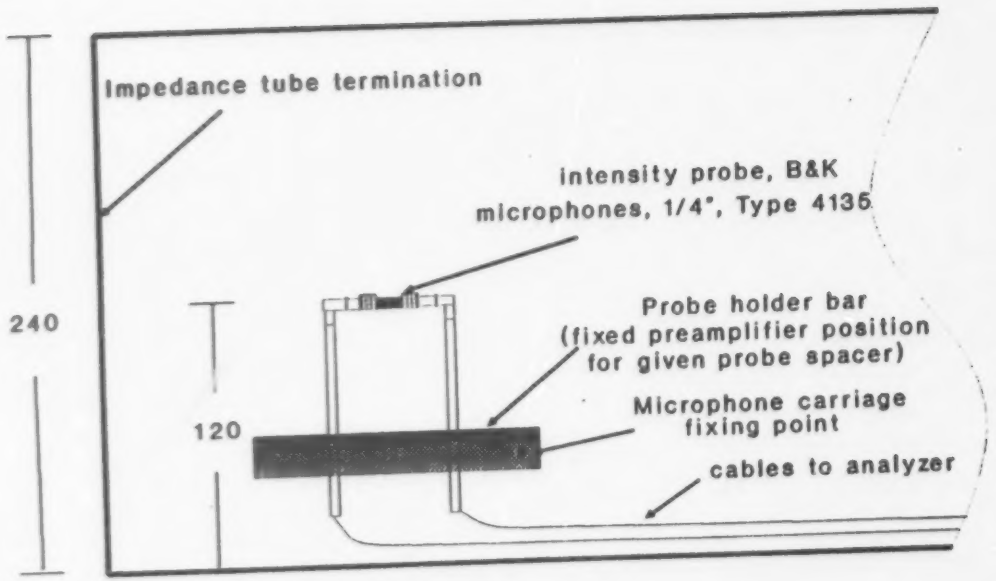


Figure B2: Mounting Configuration of the Intensity Probe inside the Impedance Tube (all dimensions in millimeters)

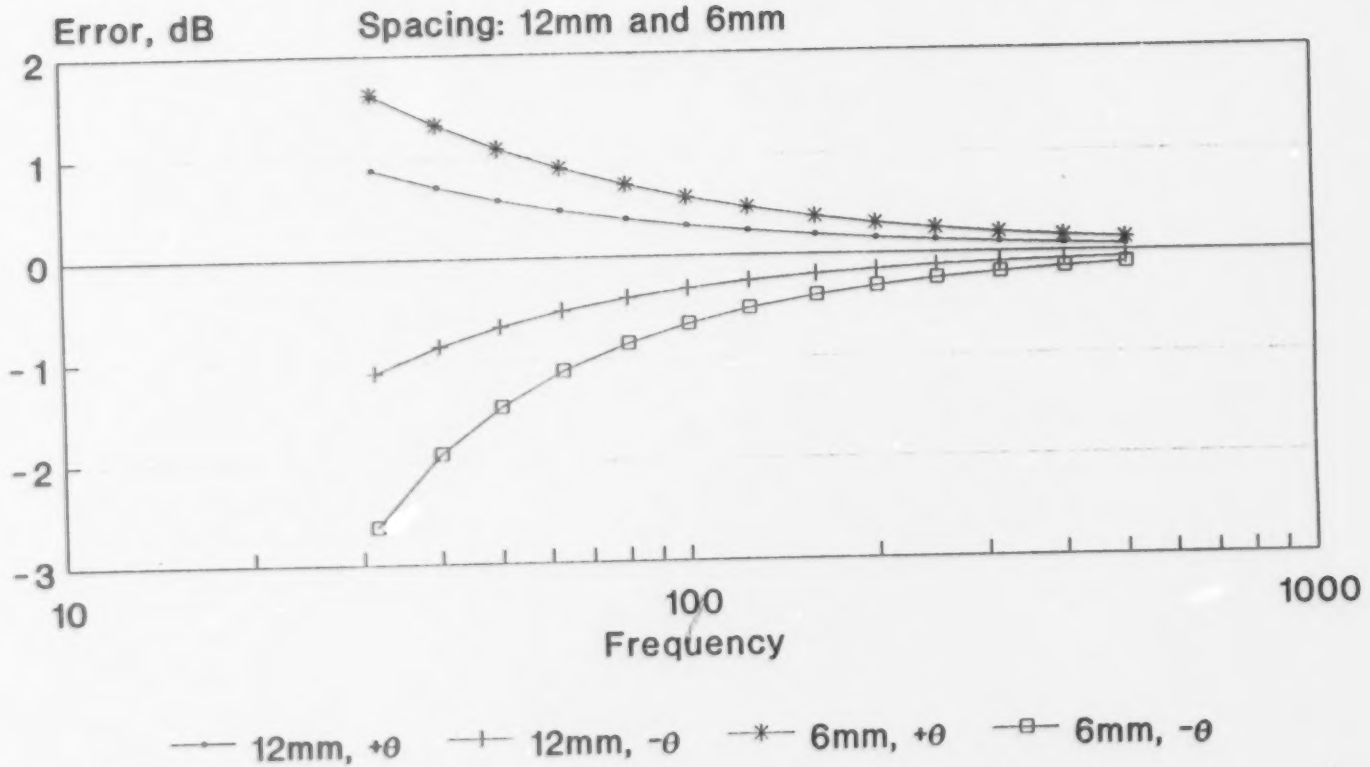


Figure 3: Predicted Intensity Error(dB) versus Frequency with Phase Error θ=0.09° in a Free-field Measurement(Equation 6).

ANNEXE C

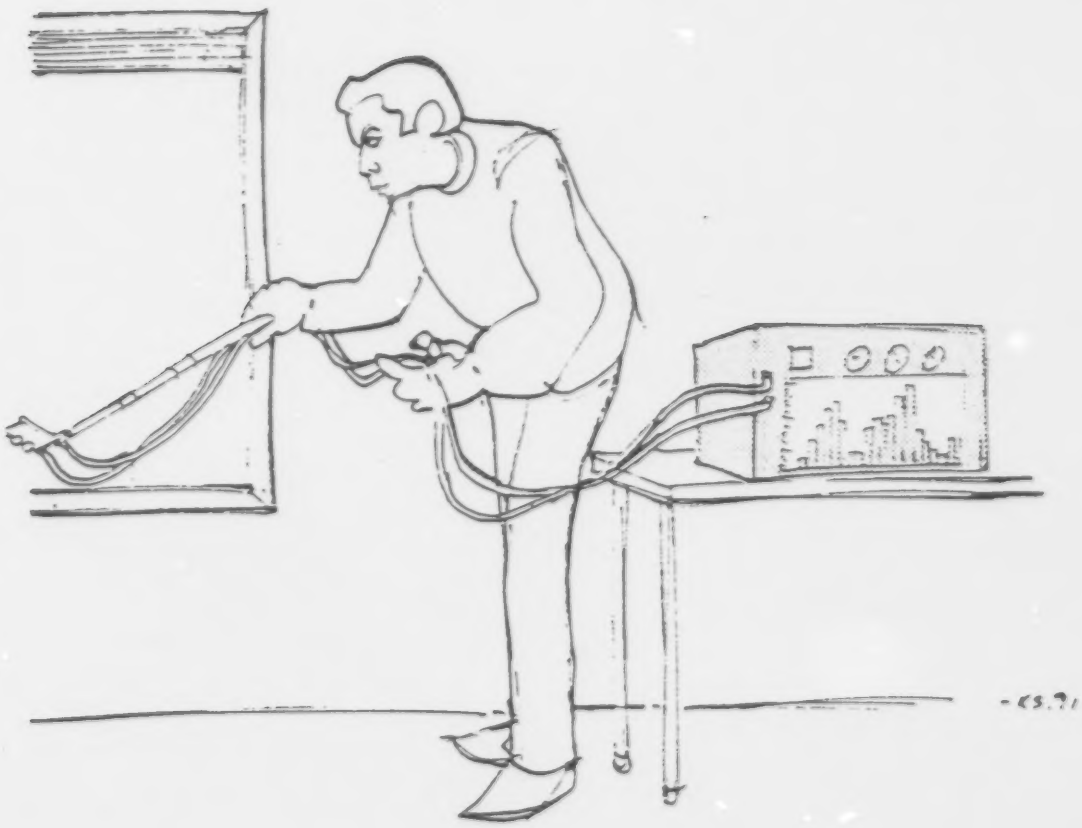
Measurements of Sound Reduction Index with Intensity Technique

Hans G. Jonasson

Appendix C

Measurements of sound reduction index with intensity technique

Nordtest Project 746-88



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Physics and Electrotechnics
SP REPORT 1991:23

7 Proposal for Nordtest method

Building elements:
Sound insulation measurements with an intensity scanning method under laboratory conditions

0 Introduction

The ISO 140 series specifies methods to measure the sound reduction index of building elements in the laboratory. This NORDTEST method is primarily aiming at being a supplement to ISO 140 to be used whenever the flanking transmission prevents accurate measurements according to that standard.

1 Scope

This NORDTEST method specifies a sound intensity scanning method to determine the sound reduction index, as defined by ISO 140/3, of a building element.

2 Field of application

2.1 General

This NORDTEST method is primarily intended to be used in the laboratory when the traditional ISO 140/3 method fails because of high flanking transmission. This may, for instance, be the case when measuring on windows, doors or heavy constructions with high sound insulation.

Relevant parts of the method can of course also be used for measurements on facade elements, suspended ceilings and small building elements according to ISO 140 Parts 5,9 and 10 respectively.

2.2 Precision

The absolute precision of this Nordtest method is not known. As the method will primarily be used in parallel with the traditional ISO 140/3 method and not as a self standing method the estimated precision iin relation to this traditional method is given in Table 1.

Frequency, Hz	Average overestimate	Standard deviation
50 Hz	5 dB	6 dB
63 - 80	1,5 dB	3 dB
100 Hz	1 dB	2 dB
125 - 400 Hz	1 dB	1,5 dB
500 - 1600 Hz	0,5 dB	1,5 dB
2000 - 3150 Hz	1 dB	2 dB
4000 Hz	1,5 dB	2 dB
5000 Hz	1,5 dB	3 dB
100 - 3150 Hz, R_W	0,5 dB	1 dB

Table 1 Estimation of the precision with which this Nordtest method will reproduce the traditional ISO 140/3 method.

Note - The estimates in Table 1 are based on about 30 comparison measurements carried out in three different Scandinavian laboratories.

3 References

ISO 140/3, Acoustics - Measurement of sound insulation in buildings and of building elements - Part 3: Laboratory measurements of airborne sound insulation of building elements.

ISO 140/5, Acoustics - Measurement of sound insulation in buildings and of building elements - Part 5: Field measurements of airborne sound insulation of facade elements and facades.

ISO 140/9, Acoustics - Measurement of sound insulation in buildings and of building elements - Part 9: Laboratory measurement of room-to-room airborne sound insulation of suspended ceiling with a plenum above it.

ISO 140/10, Acoustics - Measurement of sound insulation in buildings and of building elements - Part 10: Measurement of sound insulation of small building elements.

ISO 717, Rating of sound insulation in buildings and of building elements.

ISO 3741, Acoustics - Determination of sound power levels - Precision method in a reverberation room

IEC 942, Sound calibrators

IEC 1043, Instruments for the measurement of sound intensity(at present at the stage of draft).

4 Definitions

4.1 average sound pressure level in a room, L_p:

10 times the common logarithm of the ratio of the space and time average of the sound pressure squared to the square of the reference sound pressure, the space average being taken over the entire room with the exception of those parts where the direct radiation of a sound source or the near field of the boundaries (wall, etc.) is of significant influence.

4.2 sound intensity, I:

Time averaged rate of flow of sound energy per unit area oriented normal to the local particle velocity. This is a vectorial quantity which is equal to

$$\vec{I} = 1/T \int_0^T p(t)\,\vec{u}(t)\,dt \quad W/m^2 \qquad (1)$$

where

p(t) is the instantaneous sound pressure at a point, in pascals;

$\vec{u}(t)$ is the instantaneous particle velocity at the same point, m/s;

T is the averaging time, in seconds;

4.3 normal sound intensity, $\vec{I}_n$:

Sound intensity component in the direction normal to the measurement surface. The signed magnitude of $\vec{I}_n$ is denoted by I_n and the unsigned magnitude by $|I_n|$.

4.4 normal sound intensity level, L_{In}:

Ten times the common logarithm of the ratio of the unsigned value of the normal sound intensity to the reference intensity I_0 as given by:

$$L_{In} = 10 \lg(| \vec{I}_n | / I_0) \quad dB \qquad (2)$$

where

$I_0 = 10^{-12}$ W/m^2

4.5 pressure-intensity indicator or field indicator, F:

The difference between time and surface averaged sound pressure level and sound intensity level on the measurement surface given by:

$$F = L_p - L_{In} \; dB \qquad (3)$$

4.6 residual pressure-intensity indicator, F_0:

The difference between indicated sound pressure level and sound intensity level when the probe is placed in a sound field in such an orientation that the particle velocity in the direction of the probe measurement axis is zero(e.g. in an acoustic coupler or transverse to the direction of propagation of a plane sound wave).

4.7 sound reduction index, R:

Ten times the commmon logarithm of the ratio of the sound power W_1 incident on a test specimen to the sound power W_2 transmitted through the specimen. This quantity is denoted by R:

$$R = 10 \lg(W_1 / W_2) \; dB \qquad (4)$$

For the purpose of ISO 140/3 the sound reduction index is evaluated from

$$R = L_{p1} - L_{p2} + 10 \lg(S / A) \; dB \qquad (5)$$

where
L_{p1} is the average sound pressure level in the source room;
L_{p2} is the average sound pressure level in the receiver room;
S is the area of the test specimen, which is normally equal to the free test opening;
A is the equivalent absorption area in the receiving room.

Note - The deduction from eq. (4) to eq. (5) assumes that the sound fields are perfectly diffuse including a diffuse sound incident and that the sound is transmitted only through the test specimen.

4.8 intensity sound reduction index, R_I:

This index is evaluated from eq.(5) assuming that the sound fields are not perfectly diffuse and that the average sound pressure level in a room must include corrections for a higher energy density close to the boundaries as given in ISO 3741. In that case

$$R_I = L_{p1} - 6 - L_{In} + 10\lg(1 + \frac{S_{b2}\,\lambda}{8\,V_2}) - 10\lg(S_m / S) \qquad (6)$$

where
L_{p1} is the average sound pressure level in the source room;
L_{In} is the average sound intensity level over the measurement surface in the receiver room;
S_{b2} is the area of all the boundary surfaces in the receiving room;
λ is the wavelength of the midband frequency;
V_2 is the volume of the receiving room;
S_m is the area of the measurement surface;
S is the area of the test specimen.

If the receiving room is not defined the room correction $10\lg(1 + \frac{S_b\,\lambda}{8\,V})$ shall be applied to the source room in stead.

Note - The room correction $10\lg(1 + \frac{S_{b2}\,\lambda}{8\,V_2})$ must be used in order to simulate the same result as the traditional method.

4.9 weighted intensity sound reduction index, $R_{I,w}$:

Intensity sound reduction index R_I weighted according to ISO 717/1.

5 Instrumentation

5.1 General

The intensity measuring instrumentation shall comply with IEC 1043 and be able to measure intensity levels re 10^{-12} W/m^2 in decibels in one-third octave bands. The intensity shall be measured in real time.

The residual pressure-intensity indicator F_0 of microphone probe and analyzer shall be higher than F+10 dB.

The equipment for sound pressure level measurements shall meet the requirements of ISO 140/3. In addition the microphone in the source room must give a flat frequency response in a diffuse sound field.

Note - A 13 mm pressure microphone will normally yield satisfactory frequency response.

5.2 Calibration

In a p-p-probe both microphones shall be sound pressure level calibrated before and after each measurement series using a class 2 or better acoustical calibrator in accordance with IEC Publication 942. It is also recommended to make a corresponding intensity calibration providing such a calibrator is available and the probe build up allows it.

p-u-probes should be calibrated according to the manufacturer's instructions.

6 Arrangement

6.1 Rooms

The source room shall meet the requirements of the respective standard in the ISO 140 series. The receiving room can be any room meeting the requirements of the field indicator and the background noise, see 7.4.3 and 7.4.5.

6.2 The test specimen

The test specimen shall meet the requirements of the respective ISO-standard.

6.3 Mounting conditions

Mount the test specimen according to the requirements of the respective ISO standard.

7 Test procedure

7.1 General

The average sound pressure level in the source room and the average sound intensity level on a measurement surface in the receiver room are measured. Providing the field indicator is satisfactory the intensity sound reduction index can then be calculated.

7.2 Generation of sound field in the source room

Loudspeaker, noise and loudspeaker position(s) shall meet the requirements of the respective standard in the ISO 140 series.

7.3 Measurement of average sound pressure level in the source room

This procedure shall meet the requirements of the respective standard in the ISO 140 series.

7.4 Measurements on the measurement surface in the receiving room

7.4.1 Measurement surface

The acoustical measurements in the receiving room shall take place on a measurement surface totally enclosing the test opening.

If the test specimen is mounted in a niche the measurement surface is normally the flat surface of the niche opening flush with the wall in the receiving room. If the test

specimen is not mounted in a niche or if the depth of the niche is less than 0,1 m a boxshaped measurement surface has to be used.

Measurement distances shorter than 0,1 m shall be avoided because of the complicated near field of the vibrating element. In the near field the intensity tends to change sign very often. The sound field is also normally more uniform in the niche opening than inside the niche. When using box-shaped measurement surfaces measurement distances longer than 0,3 m shall be avoided.

7.4.2 Scanning procedure

The probe shall always be held normal to the measurement surface while scanning and it shall be directed to measure the positive intensity outwards from the building element under test.

The measurement surface shall be divided into one or more subareas. The scanning time of each subarea shall be proportional to the size of the area. The scanning shall be made with a steady speed between 0,1 and 0,3 m/s. The measurements may be interrupted when going from one subarea to another. Other stops shall be avoided.

Each subarea shall be scanned using parallel lines turning at each edge as shown in Fig. 1. The scanning line density depends on how irregular the sound radiation is. A large amount of irregularities such as leakages requires a higher line density. Normally the line density is chosen to be equal to the measurement distance.

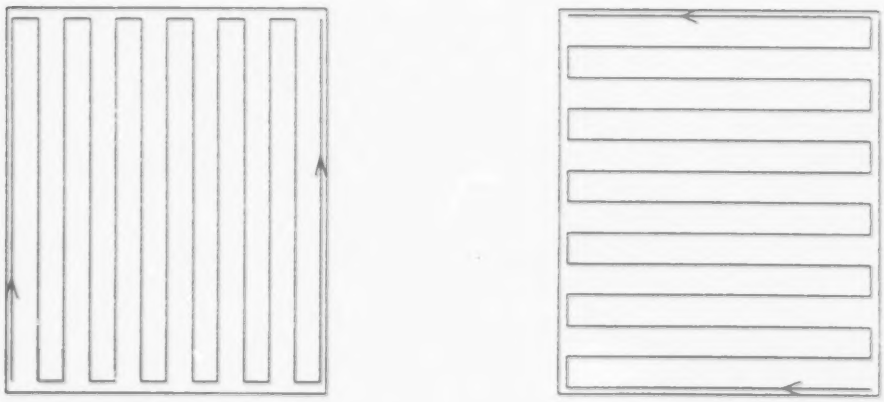


Figure 1 Scanning patterns for the two scans.

If the measurement surface is box shaped as shown in Figure 2 particular care should be given to the areas close to the intersection between the box surface and the partition wall in which the test specimen is mounted. The measurement surface must be "closed" properly, that is it is essential to scan as close as possible to the partition wall.

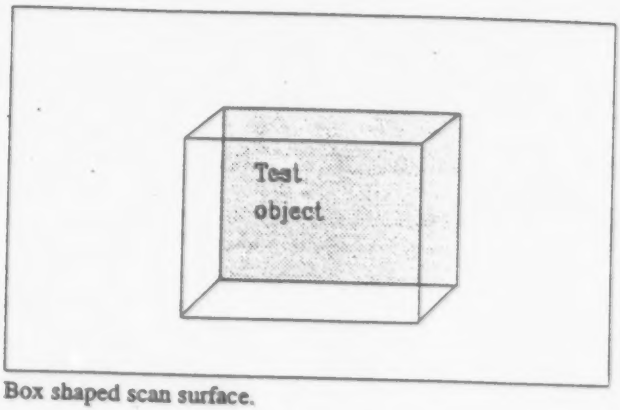


Figure 2 Box shaped scan surface.

7.4.3 Sound intensity, one scan area

During the scan the time and space integrated sound intensity level L_{In} is measured. If possible the time and space integrated sound pressure level L_p is measured simultaneously. Then the field indicator is calculated from

$$F = L_p - L_{In} \qquad (7)$$

If the measured intensity is negative or if F is not satisfactory, that is if F>10 dB for a sound reflecting test specimen or if F>6 dB for a test specimen with a sound absorbing surface in the receiver room, the measurement environment must be improved. First try to increase the measurement distance 5-10 cm. If this fails add sound absorbing material to the receiver room. The field indicator requirement is valid for each scan and each loudspeaker position. However, it is only valid for the total measurement surface and not for individual sub surfaces, see 7.4.4.

Note - As a rule of thumb F<10 db requires S / A < 1.25 where S is the area of the measurement surface, A is the sound absorption area of the receiving room.The more flanking transmission the more A must be increased.

Once the measurement environment is satisfactory two complete scans are carried out and the results are compared. The scanning path shall be turned 90 degrees between the two scans. If the difference between the two measurements is less than 1,0 dB for any one frequency band the measurement result is given by the arithmetic average of the two measurements. If the difference is larger than 1,0 dB the measurements are not valid and new scans must be carried out until the requirement is fulfilled. If the requirement cannot be fulfilled, scanning pattern, measurement surface or measurement environment must be changed and the measurements repeated until the requirement is fulfilled. If, despite these efforts, it turns out to be impossible to comply with these requirements, the results may still be given in the test report providing that all deviations from the requirements of this method are clearly stated

If two or more loudspeaker positions are used a pair of scans shall be carried out in each position. Each pair of scans shall comply with the requirements above. All results, including sound reduction index and field indicator, are given by the arithmetic mean of all scans carried out.

7.4.4 Sound intensity, several sub scan areas

If the measurement surface is divided into several sub areas, each with the area S_i and each being scanned individually, the total sound intensity L_{In} must be evaluated from

$$L_{In} = 10 \lg(\Sigma S_i \, 10^{LIi/10}) - 10 \lg(S) \quad (8)$$

where $S = \Sigma S_i$. If the sound intensity for a subarea has a negative direction, that is the flow of energy is in the direction towards the test object a minus-sign shall be inserted before the respective LIi in eq. (8).

To calculate the field indicator L_p and L_I are given by the following equations:

$$L_I = 10 \lg(\Sigma S_i I_i) - 10 \lg(\Sigma S_i) \quad (9)$$

$$L_p = 10 \lg(\Sigma S_i \, 10^{Lpi/10}) - 10 \lg(\Sigma S_i) \quad (10)$$

where

$I_i = 10^{LIi/10}$, energy flow out from the test surface (11)

or

$I_i = - 10^{LIi/10}$, energy flow towards the test surface (12)

For different loudspeaker positions or scans the procedures of 7.4.3 are then applicable.

7.4.5 Background noise

Both sound pressure level and sound intensity level shall be at least 10 dB higher than the background noise.

Note - These requirements may be tested by applying the following procedure:
If the field indicator F< 10 dB then lower the source level 10 dB. If F is changed less than 1 dB then the requirements are fulfilled.

7.5 Frequency range of measurements

The sound pressure level and the sound intensity level shall be measured using one-third octave band filters having at least the following centre frequencies in hertz:

100 125 160 200 250 315 400 500 630 800 1000 1250 1600 2000 2500 3150 4000 5000

If additional information in the low frequency range is required then third octave band filters with the following centre frequencies should be used:

50 63 80

8 Expression of results

For the statement of the airborne sound insulation of the test specimen, the intensity sound reduction indices shall be given at all frequencies of measurement to one decimal place in tabular form and in the form of a curve. In addition a curve of the pressure-intensity indicator shall always also be given in the graph. Any deviations from the basic requirement that the difference between two scans must not exceed 1 dB shall be clearly indicated. For graphs with the level in decibels plotted against frequency on a logarithmic scale, the following dimensions shall be used:

5 mm for a one-third octave,
20 mm for 10 dB.

9 Test report

With reference to this NORDTEST method the test report shall state:

a) name of organization that has performed the measurements;
b) date of test;
c) manufacturer's name and product specification;
d) description of test specimen;
e) description of details of the test opening;
f) volumes of both measurement rooms
g) air temperature in the measuring rooms (if relevant);
h) intensity sound reduction index and pressure-intensity indicator of test specimen as a function of frequency including a clear indication of any deviations from this method.;
i) brief description of details of procedure and equipment;
j) limit of measurement in case of background noise;
k) single number rating according to ISO 717
l) measurement distance and shape of measurement surface.

ANNEXE D

Brochures techniques

de certains traitements résilients

LISTE DES FOURNISSEURS DE MATÉRIAUX RÉSILIENTS

C_1 : coussins de néoprène gaufré de 50mm X 50mm, DURO 30; 14mm d'épaisseur, installés sous les points d'appui des appareils

RACAN INDUSTRIES Inc.
3737, Boul. Lite
LAVAL, Québec
H7E 4X8

Téléphone: (514) 324-5050

C_2 : revêtement de liège de 1000mm X 1000mm; Dodge Cork; 5mm d'épaisseur
C_3 : revêtement de caoutchouc recyclé de 1000mm X 1000mm; Everlast; 10mm d'épaisseur

PHOENIX, Produits pour plancher et mur
6660 Côte De Liesse
St-Laurent, Québec
H4T 1E3

Téléphone: (514) 942-3000

PF_1 : plancher flottant de 1000mm X 1000mm ; Acousti-mat
PF_2 : plancher flottant de 1000mm X 1000mm ; Enkasonic

NOMAT
3175 Boul. Industriel
Laval, Québec

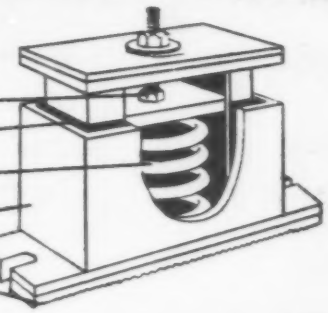
Téléphone: (514) 662-2604

PF_3 : plancher flottant de 1000mm X 1000mm ; Sonopan

Quincaillerie Val-Royal

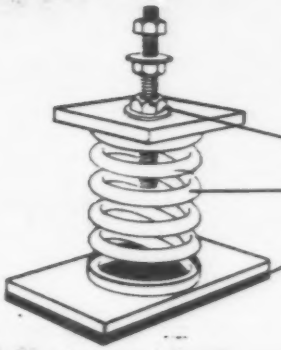
TYPES OF ISOLATION

TYPE CM



LEVEL ADJUSTMENT
RUBBER STABILIZER
COLOUR CODED STABLE SPRING
CLOSED HOUSING
RIB RUBBER PAD

TYPE FS OPEN TYPE

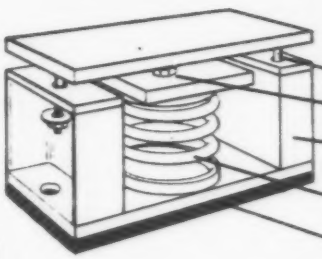


LEVEL ADJUSTMENT
"ISO-STIFF" SPRING COLOUR CODED
RIB RUBBER PAD

TYPE SH

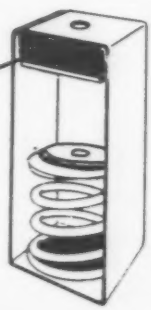
STEEL HANGER BOX
ACOUSTIC WASHER
COLOUR CODED STABLE SPRING

TYPE CSR



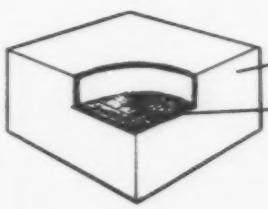
ISOLATED LIMIT STOPS
LEVEL ADJUSTMENT
WELDED STEEL CONSTRUCTION
"ISO-STIFF" SPRING COLOUR CODED
RIB RUBBER PAD

TYPE SHR



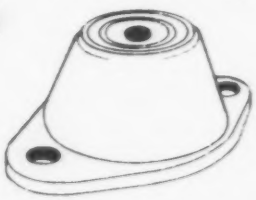
1" RUBBER ELEMENT
ALL OTHER DETAILS AS FOR TYPE SH

TYPE KIP



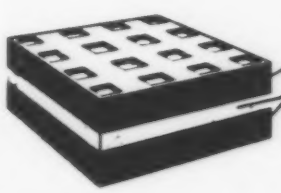
2" THICK NEOPRENE COATED
PRECOMPRESSED MOLDED GLASS FIBRES BONDED WITH PHENOLIC RESIN

TYPE RM & RDM



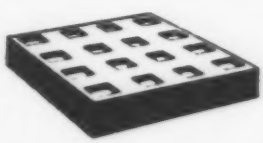
NEOPRENE-IN-SHEAR WITH THREADED INSERT AND HOLD DOWN BOLT HOLES

TYPES RSR NSN



½" ELASTOMER WAFFLE PADS
STEEL PLATE
AVAILABLE IN NATURAL RUBBER(R) 30 & 50 DUROMETER NEOPRENE (N) 50 DUROMETER

TYPE R



¼" OR ½" ELASTOMER WAFFLE PAD AVAILABLE IN NATURAL RUBBER(R) 30 & 50 DUROMETER NEOPRENE (N) 50 DUROMETER

FOR APPLICATION SEE VIBRATION ISOLATION SELECTION GUIDE VIB.020.1

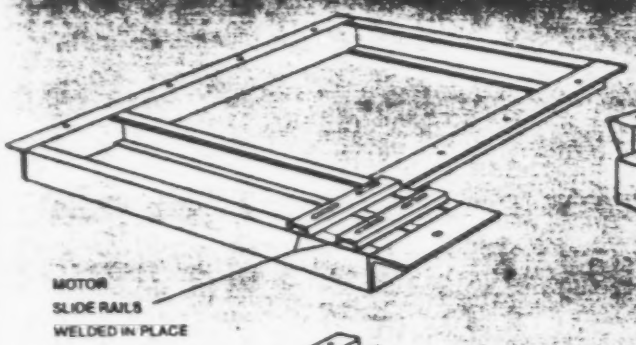
Vibro-Acoustics®

TYPICAL VIBRATION ISOLATORS

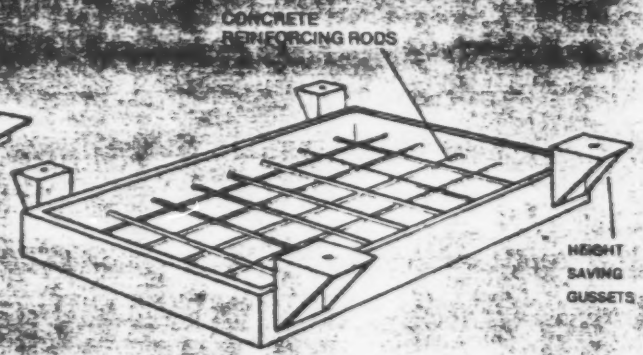
VIB - 030.1

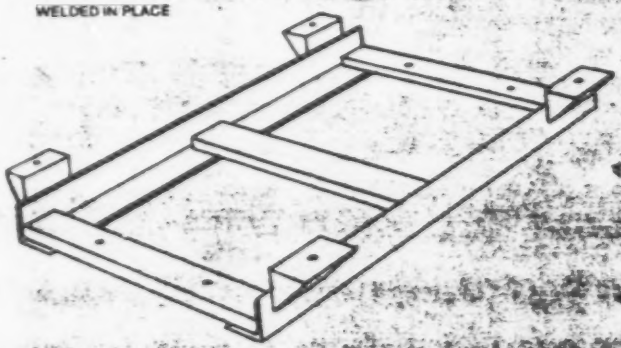
TYPES OF BASES

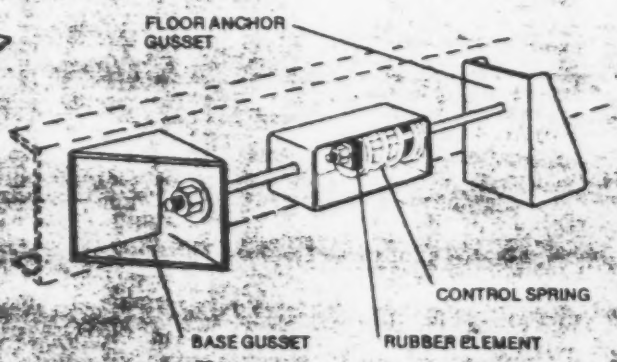
TYPE S INTEGRAL STEEL BASE
ALL WELDED CONSTRUCTION



TYPE C CONCRETE INERTIA BASE
ALL WELDED CONSTRUCTION







TYPE SS SLUNG STEEL BASE
ALL WELDED CONSTRUCTION

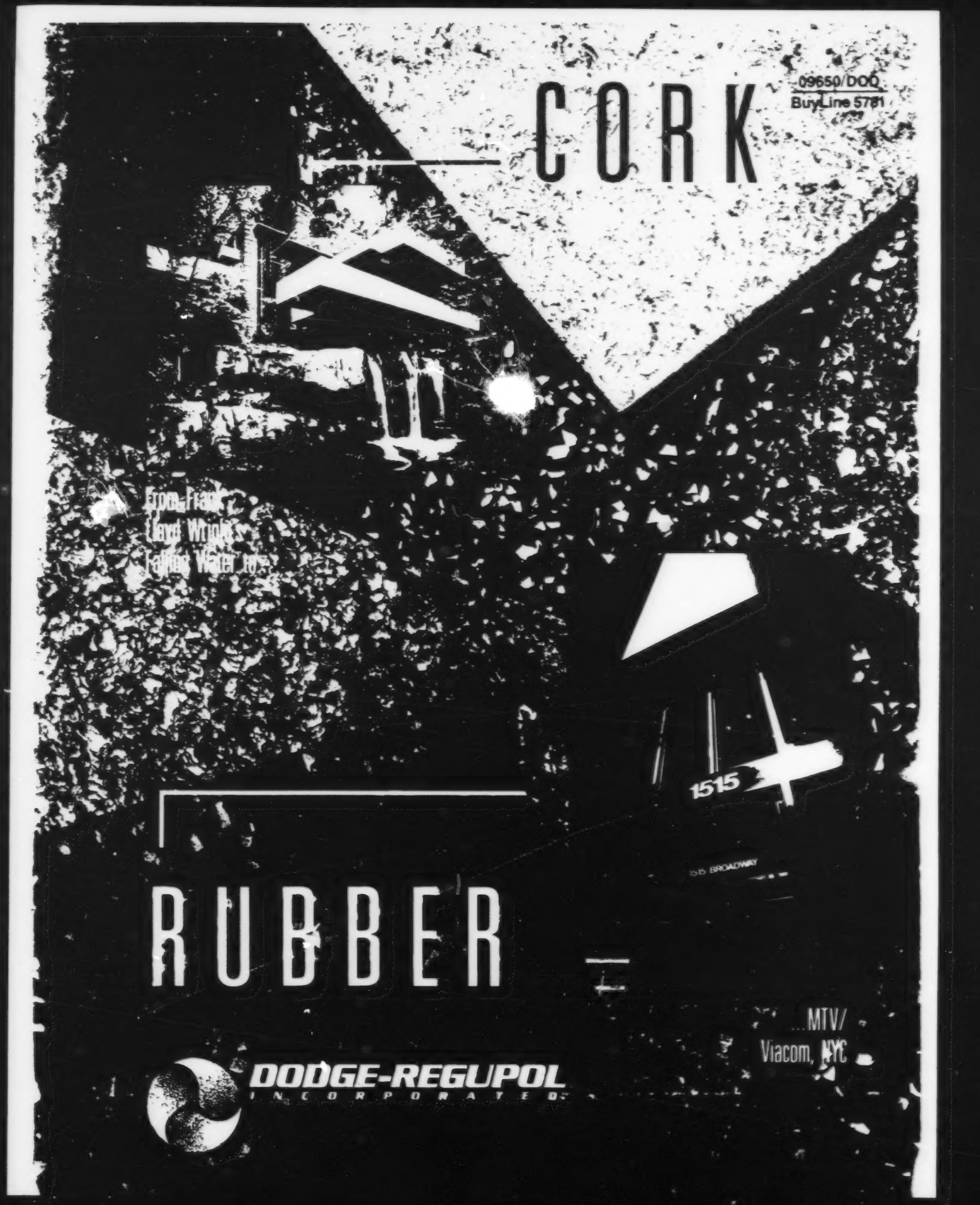
TYPE HCS TYPICAL HORIZONTAL
CONTROL SPRING

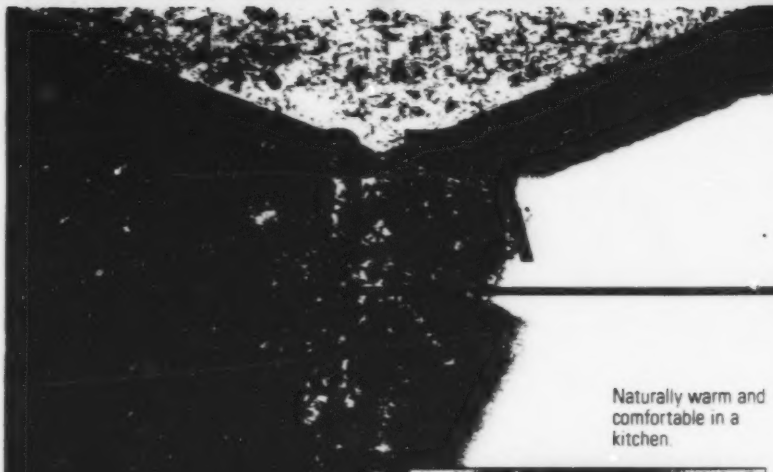
FOR APPLICATION SEE VIBRATION ISOLATION SELECTION GUIDE VIB.020.1

Vibro-Acoustics®

TYPICAL
VIBRATION ISOLATORS

VIB - 030.1


CORK
09650/DOQ
BuyLine 5781
From Frank
Lloyd Wright's
Falling Water to...
1515
1515 BROADWAY
RUBBER
...MTV/
Viacom, NYC
DODGE-REGUPOL
INCORPORATED



Naturally warm and comfortable in a kitchen.

DODGE CORK TILE

DODGE Cork Tile, It's More Than Stylish, It's Essential.

- **NATURALLY RESILIENT:** For over one hundred years, natural cork flooring has proven to be one of the most durable and resilient flooring materials available. Its unique molecular structure of compounded cork particles make it naturally impact resistant, shock absorbing and sound deadening. Ideal for kitchens, family rooms, hallways, libraries, stages, music rooms, dance floors, gymnasiums, and TV studios, DODGE Cork Tile can be used for almost any commercial or residential application.
- **TIME TESTED AND PROVEN:** From Frank Lloyd Wright's Falling Water to MTV's offices in the Viacom building, innovators have chosen DODGE Cork Tile for over 60 years. Commercial and residential installations span the country: Historic Williamsburg; the Federal Court Building, Denver; the National Archives Building, Washington, D.C.; York Community College and hundreds more. DODGE Cork Tile installations from the turn of the century to as recently as today speak for themselves.
- **FASHIONABLE AND FLEXIBLE:** DODGE Cork Tile is offered in a variety of shades: Tight random, medium random, and dark random; and a variety of finishes: naturally unfinished, polyurethane coated, and standard wax coated. DODGE Cork Tile also comes in two standard thicknesses, 3/16 in. and 5/16 in., for both residential and commercial applications.
- **MAINTENANCE FREE:** DODGE Cork Tile requires only occasional cleaning with a mild detergent and damp cloth. Periodic waxing and buffing are recommended for the standard wax coated tiles.

● **202 Medium Random**

...modates heavy
...o quiet places!

RUBBER

0968 800
Buy Line 5781

EVERLAST RUBBER TILE

Innovation And Quality Are What We Stand On, So Can You.

- **RESILIENT AND RESISTANT:** For innovative commercial and athletic applications, EVERLAST is the ideal flooring. This resilient all rubber floor tile is spike resistant, shock-absorbing, and sound deadening. From the lightest pedestrian traffic to the heaviest free weights, from ice skates to golf shoes, EVERLAST is perfect for almost any flooring situation. Use it in weight rooms, golf pro shop areas, aerobic/fitness centers, walkways and corridors, ice rinks, and locker rooms.

- **DURABLE AND LONGLASTING:** Nothing beats EVERLAST for longevity and performance. This resilient, one piece non-laminated flooring was designed with punishment in mind. If properly installed and maintained, EVERLAST will endure over ten years of heavy usage.

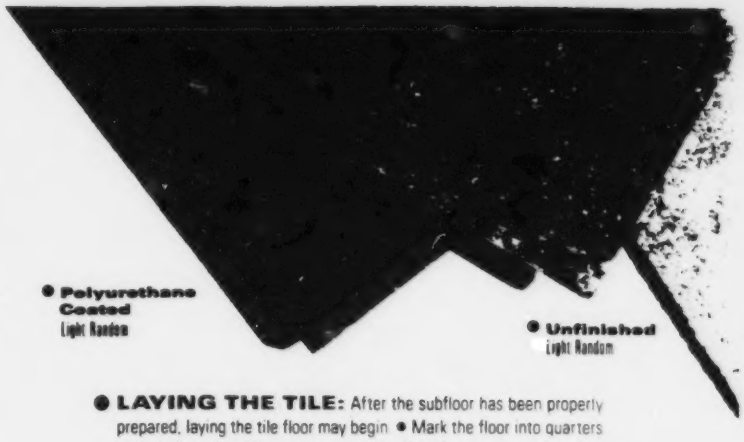
- **RECYCLED:** Unlike other rubber flooring, EVERLAST involves the urethane bonding of 100% recycled rubber particles. Every five square feet of EVERLAST rids the earth of approximately one scrap tire, helping to preserve the environment.

- **COLORFUL:** Available in a wide variety of fashionable colors, EVERLAST is the perfect choice for dramatic interior solutions. Using homogeneously blended EPDM (the highest quality colored rubber), EVERLAST provides a uniform color on a black background. This colorful resilient floor tile shows up in such notable places as the Viacom Building/MTV General Offices, NYC; General Motors Building, NYC; ABC Studios, NYC; and prestigious health clubs and golf clubs across North America.

- **FLEXIBLE AND MAINTENANCE FREE:** EVERLAST is available in tile forms 18 in. X 18 in. or 36 in. X 36 in. or in sheets and rolls up to 36 in. wide. Standard thicknesses are 1/4 in. and 3/8 in. Custom fabrication is also offered. EVERLAST requires only periodic cleaning with a mild detergent and damp cloth.

► Other Colors Available Upon Request

SPECIFICATIONS FOR DODGE CORK AND EVERLAST RUBBER TILE



● **Polyurethane Coated** Light Random

● **Unfinished** Light Random

● **TECHNICAL DATA FOR DODGE CORK TILE:**

WEIGHT: 18 lbs. per carton.
DENSITY: 30 lbs./cu. ft.
INDENTATION & RECOVERY: After 1 hr. 0.56% @ 100 psi, after 2 hrs. 0.32% @ 100 psi
COEFFICIENT OF FRICTION: Wet on leather 0.80, dry on rubber 1.00.
ACOUSTICAL RATING: Superior.
NEW YORK STATE FIRE GAS TOXICITY TEST: #0300-900216-4005.
Meets Federal Spec LLL-T-43lb Type II, Class 1.
STANDARD SIZES: DODGE Cork Tile is offered in 12 in. X 12 in. 3/16 in. or 5/16 in.

● **TECHNICAL DATA FOR EVERLAST TILE:**

WEIGHT: Approx 1.8 lbs./sq. ft. at 1/4 in. thickness, approx. 2.5 lbs/sq. ft. at 3/8 in. thickness.
DENSITY: 67 lbs. cu/ft.
SHORE A HARDNESS ASTM TEST: 60+/−5
COMPRESSION AT 100 PSI: 5 to 15.
RECOVERY: 85 min.
ELECTRIC CONDUCTIVITY: 1.1 X 10.2
CHEMICAL RESISTANCE: Unaffected by most acids and chlorine.
ABRASION RESISTANCE: (2100 cycl.): .5150.
COEFFICIENT OF FRICTION: .057 dry, .072 wet.
COMPRESSION ENDURANCE: 10,000 cycles with 4–9 ton load.
ACOUSTICAL RATING: Superior.
COLORS: Gray, Green, Red, Brown, White, Blue and Custom Blended.
NEW YORK STATE FIRE GAS TOXICITY TEST: # 090300-000216-4006.
STANDARD SIZES: EVERLAST Tile is offered in 18 in. X 18 in. (2.25 sq. ft.) or 36 in. X 36 in. (3 sq. ft.) X 1/4 in. or 3/8 in. thickness.

● **PREPARATION OF SUBFLOORS:** All subfloors should be thoroughly cleaned, filled and primed. Remove paint, varnish, oil, grease and wax. On wood floors, use a chemical paint or varnish remover. On concrete, use solution of trisodium phosphate (or xylol for rubber based paint). For oil, grease, or wax, scrub with trisodium phosphate or machine sand. In all cases, complete with thorough washing and rinsing. ● Concrete floors must be made even with latex floor fill. Fill cracks with latex crack filler. If floor is new, be sure it is completely dry (several months curing is preferred). Sweep clean. ● In wood floors, fill cracks with plastic wood, sand uneven boards, renail loose boards, or replace where necessary, and prime with floor size. If needed, floor may be covered with 5-ply 5/8 in. plywood or hardboard, or covered with latex floor fill. Single wood floors of tongue and groove construction should be completely covered with latex floor fill or hardboard or plywood, and primed with floor size.

● **LAYING THE TILE:** After the subfloor has been properly prepared, laying the tile floor may begin. ● Mark the floor into quarters with chalk and lay tile a quarter at a time. Start from center and work to borders. Follow lines of permanent fixtures. For protective edges use bevelled edging.

● **FOR EVERLAST TILE:** Spread adhesive, being a Synthetic Surfaces #78H Epoxy or equal, in accordance with the instructions provided with the adhesive. Please note, Synthetic Surfaces #78H Epoxy is a non-solvent adhesive and a material safety data sheet is available from the manufacturer upon request. Press the tile firmly to adhesive and butt to adjacent tile. Roll with 100 lb. roller. Remove excess adhesive. When floor is completed, roll again.

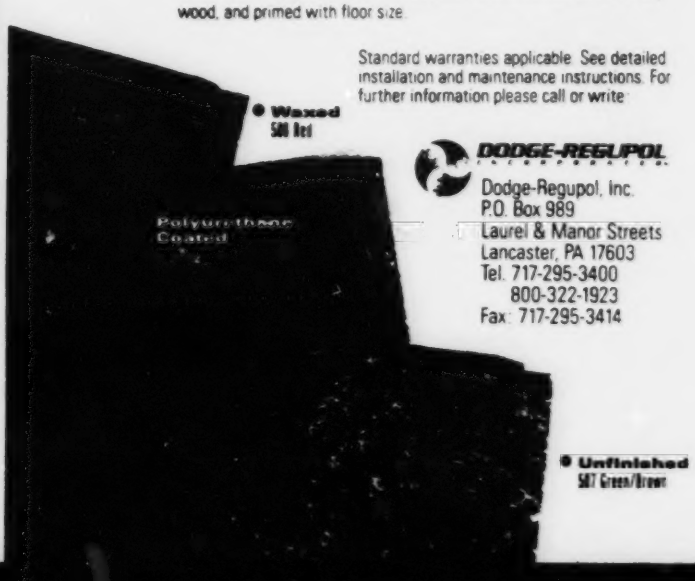
● **CAUTION:** 1. Avoid abrasive alkaline or cheap cleaners. 2. Keep surface free of grit, sand and cinders. 3. Protect against indentation from furniture, by using furniture rests. 4. Finished floors should not be exposed to direct sunlight or high intensity lamps as fading may occur.

● **FOR DODGE CORK TILE:** Spread adhesive, being W.W. HENRY 356 or equal, in accordance with instructions provided with the adhesive. Press tile firmly to adhesive and butt to adjacent tile. ● DO NOT FORCE OR COMPRESS TILE. Roll with 100-lb. roller. Remove excess adhesive. When floor is completed, roll again.

● FINISH NO. 6300, DO NOT START the finish process for at least 5 days. Series No. 6300 is an unfinished tile and will require a protective coating. You have a choice of using paste wax or polyurethane. ● A light sanding may be required if you have uneven only, as it should not be necessary to sand the entire floor as No. 6300 is factory sanded. Any uneven or high edges can be corrected by light sanding with no. 80 Mesh Disc. Sander—3M or equal and a very light sanding with No. 150 fine sandpaper.

● Apply your finish. If you use wax, you can use any paste wax that is recommended for use with wood floors, as cork is a natural wood product. Follow the same for polyurethane finish. Always follow the recommendations of the finish manufacturer. When applying urethane, 3 or 4 coats may be required to obtain the finish you desire. For small areas, we recommend the polyurethane as produced by Min-Wax as it has a very good drying time and 2 coats can be applied the same day. For larger areas, use any polyurethane that is recommended for Unfinished Hardwood Flooring Systems.

● **CAUTION:** 1. MOISTURE CAN CAUSE PROBLEMS. A. Moisture on the slab cannot exceed 2% max. B. Airborne moisture cannot exceed 65% R.H. 2. Avoid abrasive alkaline or cheap cleaners. 3. Keep surface free from grit, sand and cinders. 4. Avoid floating the floor with water. 5. Protect against indentation from furniture rests. 6. Cork is a natural wood product and may have some shade variation from photograph to tile. 7. Cork floor tile must be acclimatized prior to installation. We recommend the tile be removed from the cartons and plastic sleeves at least 72 hours prior to installation and the temperature should be maintained between minimum 60°F., max. 85°F., and the relative humidity should be maintained between 50% and 65%.



Standard warranties applicable. See detailed installation and maintenance instructions. For further information please call or write:

DODGE-REGUPOL INCORPORATED
Dodge-Regupol, Inc.
P.O. Box 989
Laurel & Manor Streets
Lancaster, PA 17603
Tel. 717-295-3400
800-322-1923
Fax: 717-295-3414

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Les Industries GESCO Inc.
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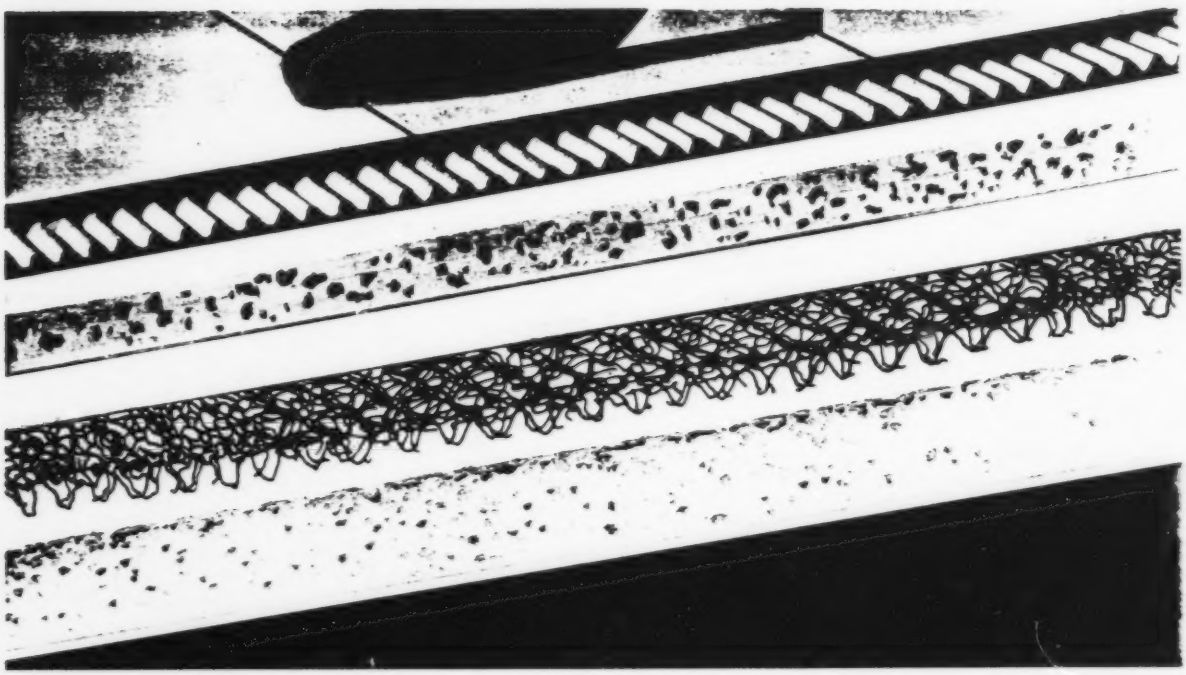
St-Laurent, Québec
H4T 1E3
Tel.: (514) 342-3000
Fax: (514) 733-5800

ited in U.S.A.

13080 AKZ
BuyLine 1778

Enkasonic

Sound Control Matting



Tested for use between floors under:

- Ceramic Tile
- Marble
- Native Stone
- Hardwood
- Vinyl Tile
- Wood Parquet
- Carpet and Pad

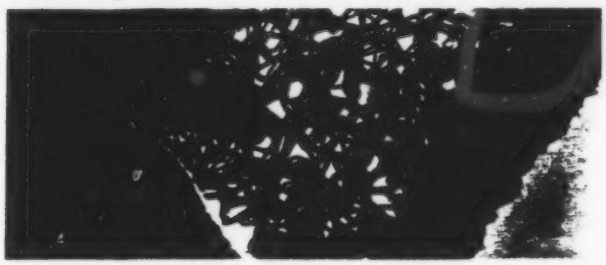
AKZO

Gaining Ground Through Ingenuity

Enkasonic®

Sound Control Matting

Enkasonic sound control matting is a proven solution to a modern design challenge—creating floor systems that meet stringent sound ratings in multiple-story dwellings or buildings. Enkasonic effectively inhibits sound transmission when



used beneath ceramic tile, marble, wood, vinyl, or carpet flooring, in both wood frame and concrete slab construction.

Enkasonic is a 0.4" thick composite of nylon filaments forming a three-dimensional geomatrix with a nonwoven fabric heat bonded to the upper surface. The durable pliable Enkasonic obstructs transmission of sound and makes possible cost effective sound-rated floors. Because of its thin cross-section, it's ideal for new construction and retrofit, and costs less than a "built-up" floor to achieve the same sound ratings.

Before development of reasonably priced sound-rated floor systems, developers often avoided hard surfaces. It is now possible to ensure the privacy of tenants in multistory buildings with Enkasonic floor systems.

Floor/ceiling assemblies are subjected to two types of noise: airborne sounds, like speech or music (STC), and impact noise, typically from footfall (IIC). To block both mass alone may not be enough.

ENKASONIC...

Ideal for

- Retrofit Design
- New Floors
- Athletic Floors
- Vibration Areas
- Parking Decks
- Sound Studios

Enkasonic is a sound investment, easy to transport, cut and install

Enkasonic, sandwiched between subflooring and support overlay, now gives designers the option of using hard surface flooring where STC and IIC ratings must be above 50 (UBC Code).

Enkasonic, sandwiched between the subflooring and a support overlay (such as a reinforced mortar bed, Wonder-Board®, Gyp-Crete®, or 2 layers of plywood), now gives designers the option of using hard surface flooring where STC *and* IIC ratings must be above 50.

The Enkasonic floor

Sound Ratings–Tested Enkasonic Floor/Ceiling Assemblies

Concrete Floor System

Test Reference	Subfloor	Susp. Ceiling	Enkasonic Overlay	Floor Covering	STC	IIC
Akzo C-11	4" slab	no	7/16" Wonder-Board	tile	55	52
CTI #11	8" slab	no	7/16" Wonder-Board	tile	59	52
CTI #8	8" slab	yes	1 1/4" mortar bed	tile	61	62
CTI #12	8" slab	no	1 1/4" mortar bed	tile	60	54
AKZO C-1	8" slab	yes	1 1/4" mortar bed	vinyl tile	61	67
AKZO C-2	8" slab	yes	1 1/4" mortar bed	carpet & pad	61	79
AKZO C-3	8" slab	yes	1 1/4" mortar bed	5/16" wood parquet	61	65
AKZO C-4	8" slab	yes	2 layers—3/8" plywood	3/4" T&G oak	60	61

Wood–Joist Floor System

CTI #5	5/8" plywood	yes	7/16" Wonder-Board	tile	62	58
CTI #7	5/8" plywood	yes	1 1/4" mortar bed	tile	60	55
AKZO W-3	5/8" plywood	yes	1 1/2" Gyp-Crete® 2000[1]	tile	59	57

1. Noble Seal™ TS isolation membrane or equivalent is bonded to the Gyp-Crete 2000 prior to thinsetting the tile.
CTI listings refer to the Ceramic Tile Institute's Sound-Rated Floor Systems per bulletin CTI-R5-113-79. Details about the Sound-Rated Floor Systems listed above and ***others*** *are available upon request.*

system creates a "floating floor" that not only breaks the sound transmission path through the floor-ceiling assembly but also prevents lateral transmission through the floor-wall contact area.

Prior to installing Enkasonic,® the perimeter of the subfloor along the baseboard area is lined with polyethylene foam or fiberglass board to isolate the "floating floor" and eliminate flanking noise that could be conducted through the walls. Sound suppression in Enkasonic is accomplished when the resilient nylon geomatrix converts and stores vibrational energy.

Enkasonic was designed in conjunction with the Ceramic Tile Institute (CTI) specifically for use under ceramic tile. Over the years, additional testing has demonstrated outstanding sound attenuation with a variety of construction assemblies and floor coverings, including marble, native stone, vinyl tile, parquet, and hardwood.

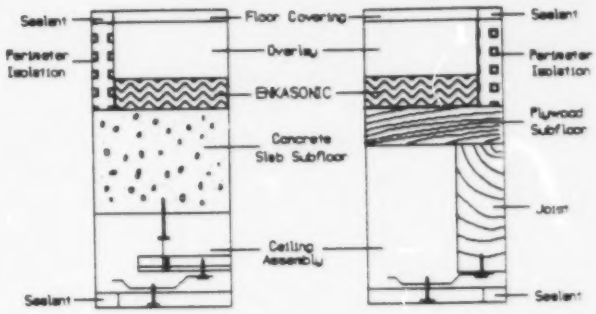
Case Study: Coca-Cola® Headquarters

When Coca-Cola decided to add a million square feet to its corporate headquarters in Atlanta, acoustical consultants recommended Ekasonic sound control matting. In one section of the new structure, a 1,400-seat cafeteria, an employee store, and other hard-surface floors were located directly above an auditorium and conference center. The cafeteria had to have hard tile floors; carpeting was judged unacceptable in terms of durability and sanitation. A conventional floating floor would have been too expensive and, because of its thickness, would not match the adjacent, existing building or the non-floating floors of the construction. Enkasonic provided effective isolation to the 20,000 square-foot area with little addition in overall thickness.

The use of Enkasonic allowed Coca-Cola designers to install a tile-floor cafeteria above an auditorium and conference center.

Coca-Cola is a registered trademark of The Coca-Cola Company

Generalized Enkasonic Sound-Rated Floor System



Concrete Floor System Wood-Joist Floor System

Floor coverings: Ceramic tile
Marble
Stone
Vinyl composition tile
Wood block parquet
Carpet and pad
Tongue-&-groove hardwood

Enkasonic overlays:
- 1¼" mortar bed reinforced with 2" x 2" x 16/16 gauge welded wire mesh
- (or) • 7/16" Wonder-Board (glass mesh mortar) units
- (or) • 1½" GYP-CRETE
- (or) • 2 layers of ⅜" plywood (hardwood floors only) (See Note 8)
- (or) • 2 layers of ⅝" plywood (for vinyl sheet installations when mortar bed or GYP-CRETE not feasible)

Subfloors: ⅝" plywood
4" to 8" concrete slabs

Perimeter isolation: ⅜"-thick fiberglass board, 6-15 pcf or 1¼"-thick polyethylene foam (e.g., AMCEL™ 27), 2.7 pcf

Sealant: Acoustical or elastomeric

Ceiling assembly below (all cases except CTI 11 & 12 and AKZO C-11): 3½" (R-11) fiberglass insulation packed between joists (wood subfloors only) ⅝" gypsum board installed in accordance with manufacturer's directions over resilient channels or T-bar channels. Acoustical sealant at the perimeter of ceiling gypsum board and around any protrusions.

All Enkasonic overlays are compatible with either concrete or wood-joist floor systems. Enkasonic floor systems are particularly effective in the retrofit market, since the total composite between the subfloor and the wearing surface can be as thin as ¾" if Wonder-Board® is used as the Enkasonic overlay.

Akzo or its authorized representative will provide technical support to your contractor to help ensure that our Enkasonic floor systems are installed properly.

Enkasonic®

Installation Summary

1) The subfloor must be structurally sound. Deflection should not exceed 1/360 of the span, including live and dead loads.
2) Install polyethylene foam or fiberglass board at the perimeter of the entire subfloor and around any protrusions through the installation. This isolates the floor and breaks the sound transmission path between floor and walls. Tape or tack-glue the isolation material.
3) Enkasonic is installed with black matrix down, fabric up. Adjoining edges of the black matrix should be butted together with the fabric overlap taped or glued to the adjacent strip.
4) A cleavage membrane (4-mil polyethylene film) or 15-lb. roofing felt is required between Enkasonic and MORTAR BED.
5) MORTAR BED should be 1 part portland cement and 5 parts damp sand, by volume.
6) When overlay is GYP-CRETE, the fabric portion of the Enkasonic should be preconditioned per manufacturer's direction.
7) WONDER-BOARD should be placed on top of Enkasonic with a ¼" gap between units, taped on both sides of joints (2" coated fiberglass tape), and butt-bonded with latex portland cement bond coat.
8) PLYWOOD should be ⅜ in. for hardwood floor installations (⅝ in. for carpet and pad). APA rated sheathing, with 2 layers at 90 degrees to one another, joints gapped and offset, top sheet glued (full coverage, non-water based) to bottom sheet. The two layers are fastened with screws in corners and center or with staples (1" wide crown/6" o.c.) with no penetration into the Enkasonic.
9) Bond coat for CERAMIC TILE is dry-set mortar or latex/portland cement mortar on a cured bed.

STC and IIC rating for other Enkasonic sound-rated floor systems are available upon request.

Note: STC ratings done in accordance with ASTM E90 or E336 and E413

IIC ratings done in accordance with ASTM E492

All CTI sound-rated floor systems utilizing Enkasonic have successfully met the performance requirements of ASTM C627, with ratings from residential to heavy commercial.

GYP-CRETE® is a trademark of the Gyp-Crete Corp, Hamel, MN (612) 478-6072.

Wonder-Board® is a trademark of Modulars, Inc., Hamilton, OH (513) 868-7300.

Ceramic Tile Inst. (CTI) Los Angeles, CA (213) 660-1911

Noble Seal™ TS is a trademark of the Noble Co., Grand Haven, MI (616) 842-7844.

AMCEL™ 27 is a trademark of American Excelsior Company, Arlington, TX. (817) 640-1555.

Nominal Dimensions And Weights

Material:	Nylon 6
Width:	39 in. (plus 3 in. fabric overlap)
Length:	111 ft
Area:	360 ft²
Thickness:	0.4 in.
Roll Diameter:	27 in.
Gross Roll Weight:	58 lbs.
Total Weight:	22.9 oz/yd²
Matrix Weight:	19.4 oz/yd²
Fabric Weight:	3.5 oz/yd²

Deflection

Deflection characteristics of the most pliable of the CTI approved Enkasonic Sound-Rated Floor Systems; Case #5—Enkasonic overlain by Wonder-Board®

Pressure (psf)	Deflection (in.)
100	0.028
200	0.046
300	0.061
400	0.075
500	0.087
1000	0.131
2000	0.189
4000	0.256

Flammability

ASTM E84 NFPA Class A Flame Spread Index 15

Standards

Tile Council of America, Inc.	RF900-89
New York City Dept. of Buildings	MEA 144-89-M
Ceramic Tile Institute	CTI-R4-113-79

Design And Installation Assistance

This brochure is intended as a general information piece. For technical help, specific information, or the name of our nearest distributor, please call or write: Akzo Industrial Systems Company, P.O. Box 7249, Asheville, North Carolina 28802, (704) 665-5050.

We believe the information contained herein to be reliable and accurate for applications of ENKASONIC®. Since conditions vary with each site, however, Akzo makes no guarantee of results and assumes no obligation or liability for such results, the suitability of the material or the information contained herein for the use contemplated, unless specifically made in writing by Akzo, or for safety or other damages occurring in connection with any installation. Furthermore, Akzo's liability under any claim shall be limited to the cost of the ENKASONIC materials or replacement thereof, at Akzo's option. This publication is not a license under which to operate and is not intended to suggest infringement upon or use of any existing patents or trademarks.

ENKASONIC is a registered trademark of Akzo Industrial Systems Co and is covered by a number of U.S. patents.

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8/90 ES-8M

• SONOPAN

ACOUSTIC PANEL

les matériaux Cascades inc

ACOUSTIC PANEL

DÉCOUVRIR SONOPAN

[illegible] aujourd'hui, [illegible] que la qualité d'une habitation se traduit également par le confort et la salubrité de son environnement sonore. Soucieux de répondre à [illegible] dans ce domaine, Matériaux Cascades Inc., en collaboration avec le Laboratoire Acoustique Architectural 3D Inc., spécialistes en acoustique du bâtiment, ont développé le nouveau panneau acoustique «SONOPAN» dont l'une des grandes propriétés est d'agir comme une véritable barrière du son dans tout type de murs ou de planchers.

UN PRODUIT INNOVATEUR

Fabriqué à base de fibres de bois et de papier recyclé, le panneau acoustique SONOPAN est un produit naturel qui ne contient aucun agent toxique. Il ne nécessite donc pas le port de gants, de masque ou de vêtements ajustés lors de la pose.

Léger et facile à manoeuvrer, le panneau SONOPAN est offert en format de 4' X 4' (plafonds), 4' X 8' et 4' X 9' (murs et planchers). D'une épaisseur de 3/4", il a une densité moyenne de 15 lbs/pi.cu.

UNE EFFICACITÉ MAXIMALE

Fruit de longues recherches en usine et en laboratoire, le panneau acoustique SONOPAN réunit plusieurs caractéristiques qui lui assurent une efficacité maximale.

- **Un procédé unique de gonflage de la fibre de bois permet d'augmenter de façon notable le coefficient d'absorption sonore.**
- **Une perforation calculée de chacun des panneaux optimise la surface d'absorption du son.**
- **Doté d'une structure fibreuse rigide, le panneau acoustique SONOPAN ne s'affaisse pas et augmente donc l'étanchéité sonore pour tout type de cloisonnement.**
- **[illegible]installation facile et rapide, il est d'une grande [illegible] il se coupe et se scie facilement, se [illegible]ment. Ce qui se traduit par [illegible]'énergie sur le**

DISCOVER SONOPAN

Today the comfort of a home is determined by many factors and one of the most important is the quality of its acoustic environment.

Attentive to the growing needs in this area, Matériaux Cascades Inc., in collaboration with the Laboratoire Acoustique Architectural 3D Inc., specialists in building acoustics, have developed the new acoustic panel "SONOPAN". The panel's most important property is its ability to act as a sound barrier in all types of walls and flooring.

AN INNOVATIVE PRODUCT

The SONOPAN acoustic panel is a natural product manufactured from wood fibres and recycled paper. Gloves, masks, or other protective clothing are not necessary for installation as the panel contains no toxic agents.

Light and easy to handle, the SONOPAN panel is available in 4' X 4' (ceilings), 4' X 8' and 4' X 9' (walls and floors) formats. Each panel has a thickness of 3/4" with an average density of 15 lbs./cu.ft.

MAXIMUM EFFICIENCY

The result of extensive laboratory and factory research, the SONOPAN acoustic panel combines many important characteristics to ensure maximum efficiency.

- *A unique procedure used to expand the wood fibres significantly increases sound absorption.*
- *Specifically calculated perforations in each panel result in optimum sound absorption.*
- *A rigid fibrous structure resists compression and increases the sound resistance quality of all types of partitions.*
- *Fast and easy to install, it can be cut or sawed, screwed or nailed thus saving time and energy on the job site.*
- *The panel adapts easily to all wood, metal, or concrete wall and floor structures.*

[illegible] absorbers avec une efficacité [illegible] sonore environnante. Dans une [illegible] le panneau doit être [illegible] la surface perforée [illegible] l'assemblage. Il est fixé de façon similaire à une planche de gypse, soit une vis aux 16" au périmètre et de 6 à 8 vis au centre.

Il en va ainsi dans une composition de plancher où le panneau SONOPAN peut être installé au-dessus des solives, les perforations étant ainsi dirigées vers le bas. Placé en-dessous des solives, les perforations seront alors dirigées vers le haut, en contact avec l'air de la cloison. (Voir le schéma 1 ci-dessous)

Le schéma 2 permet de mieux visualiser les compositions de murs simples et de murs plus complexes.

Un côté identifié aux 16" c/c et 24" c/c permet une localisation facile et rapide des solives et colombages lors de son installation. Poser un pare-feu temporaire lors de la soudure de la tuyauterie.

N. B.: Le panneau SONOPAN est sujet à l'approbation d'un ingénieur en structure pour l'installation du produit sous les murs porteurs.

[illegible] of the SONOPAN acoustic [illegible] provides maximum absorption of airborne [illegible]. When constructing a wall, the panel must be [illegible] with the perforated surface facing the air space in the assembly. Like gypsum board, it is installed with screws every 16" around the perimeter and 6 to 8 screws along the centre of the panel.

This principle should be used in the construction of floors, where the SONOPAN panel is installed above the joists, the perforated surface will face downward. When installed below the joists, the perforations should be facing upward. (See diagram 1 below)

Diagram 2 better illustrates the construction of standard and more complex walls using the SONOPAN acoustic panel.

One side of the panel is marked every 16" and 24" on centre, which allows easy location of joists and studs during installation. Install temporary fire guard when soldering pipes.

N. B.: The use of the SONOPAN panel under load-bearing walls must be approved by a structural engineer.

[illegible] ITS ET IIC

[illegible] de transmission du son (ITS) et l'indice d'isolement au bruit de choc normalisés (IIC), mesurés en décibels, permettent de classifier l'atténuation moyenne du bruit, par exemple, de la voix traversant un mur ou un plancher. Plus l'indice est élevé, plus le bruit est atténué.

Lorsque l'indice est accompagné d'un «F», la mesure a eu lieu sur place, c'est-à-dire dans un bâtiment et non pas en laboratoire.

Exemples:
Imaginons une discussion à voix élevée d'un côté d'une cloison mitoyenne. Voici ce qui sera perçu de l'autre côté.

FITS 45 Perçu de façon intelligible
FITS 50 Perçu de façon non-intelligible
FITS 55 Non perçu

Note:
Les indices présentés dans ce document proviennent de résultats de tests effectués par le CNRC et le LABORATOIRE ACOUSTIQUE ARCHITECTURAL 3D INC.

STC AND IIC RATINGS

Sound transmission class (STC) and impact insulation class (IIC) are used to classify the average noise reduction in decibels for sounds like the human voice passing through a wall or floor. The higher the rating, the more the noise is reduced.

A rating preceded by the letter "F" indicates that the measurement was made in the field, i.e. in a building and not in a laboratory.

Examples:
Imagine a **loud conversation** on one side of a dividing wall. The following ratings indicate the sound perceived on the other side.

FSTC 45 Conversation intelligible
FSTC 50 Conversation unintelligible
FSTC 55 Conversation inaudible

Note:
The ratings in this document are taken from the results of tests conducted by the CNRC and the LABORATOIRE ACOUSTIQUE ARCHITECTURAL 3D INC.

SCHÉMA 1 - COMPOSITIONS DE PLANCHERS / *DIAGRAM 1 - COMPOSITION OF FLOOR STRUCTURES*

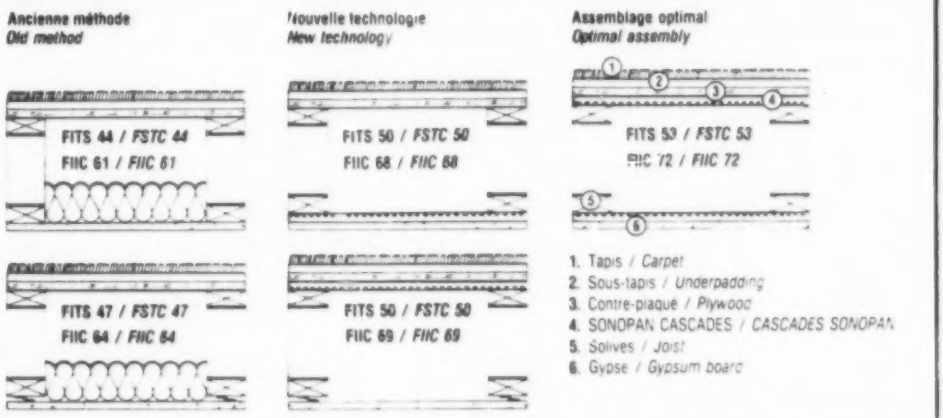
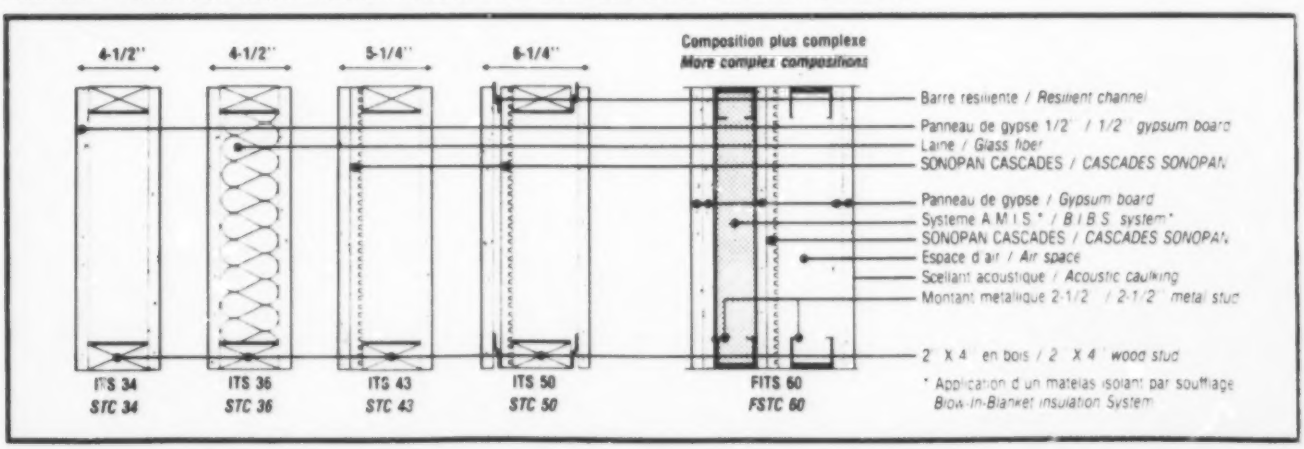


SCHÉMA 2 - COMPOSITIONS DE MURS / *DIAGRAM 2 - COMPOSITION OF WALL STRUCTURES*



Normes utilisées pour réaliser les tests acoustiques:
FSTC
ASTM E-336-84, E-413-87
FIIC
ASTM E-989-89, E-1007-89

Prenez note:
Les indices de transmission du son et d'isolement au bruit de chocs normalisés ont été établis dans des environnements contrôlés. La présence de certaines failles acoustiques (aux jonctions des murs, planchers et plafonds) peut faire varier de façon notable les indices établis. Pour s'assurer des rendements souhaités, nous mettons à votre disposition le support technique de nos spécialistes en acoustique.

Specifications used in acoustic testing:
FSTC
ASTM E-336-84, E-413-87
FIIC
ASTM E-989-89, E-1007-89

Important:
The sound transmission class (STC) and impact insulation class (IIC) ratings are established in controlled environments. Sound leakage (at junction of walls, floors, and ceilings) may significantly alter these ratings. Our acoustic specialists are available to provide technical assistance to ensure best results.

TESTS DE COMPRESSION** / *COMPRESSION TESTS***

Pourcentage de compression / *Percentage of compression* (%)	Force exercée / *Pressure applied* (lb/po²) / (*lb./sq.in.*)
5	7.7
10	20.2
15	39.0
20	63.6
25	95.8
30	135.6
35	184.3
40	246.7

Recouvrement après deux heures: 91% / *Recovery after two hours: 91%*

** En concordance avec la norme ASTM D-3501 / *In accordance with ASTM D-3501 specifications*

FICHE TECHNIQUE DU PANNEAU ACOUSTIQUE SONOPAN CASCADES / *TECHNICAL DATA FOR THE SONOPAN ACOUSTIC PANEL*

Épaisseur / *Thickness**	**3/4"**
Absorption d'eau / *Water absorption**	**7% à 10% (max.) / *7% to 10% (max.)***
Conductivité thermique / *Thermal conductivity**	055 (W/M°K)
Facteur R* (3/4") / *R Factor* (3/4")	2.1
Densité / *Density**	15 lbs/pi.cu. / *15 lbs./cu.ft.*
Couleur / *Colour*	Vert / *Green*

* En concordance avec la norme ASTM C-209 / *In accordance with ASTM C-209 specifications*

PANNEAUX SONOPAN / CHARGEMENT DE CAMION / *SONOPAN PANELS / TRUCKLOAD*

Format / *Format*	Feuilles/palette / *Sheets/pallet*	Palettes/camion / *Pallet/truck*	Surface totale / *Total surface*
4' X 4'	65	44	45760 pi²/camion / *45,760 sq.ft./truck*
4' X 8'	65	22	45760 pi²/camion / *45,760 sq.ft./truck*
4' X 9'	65	20	46800 pi²/camion / *46,800 sq.ft./truck*

En instance de brevet / *Patent pending*

RENSEIGNEMENTS

Au delà des excellents produits qu'elle fabrique, Matériaux Cascades inc. met à votre disposition son équipe de spécialistes afin de vous aider à sélectionner les produits les mieux adaptés à votre budget.

Pour plus d'information, n'hésitez pas à communiquer avec le service des ventes de Matériaux Cascades inc.

INFORMATION

In addition to its excellent products, Materiaux Cascades Inc. has a team of specialists available to help you choose the products best adapted to your needs.

For more information, please contact the Materiaux Cascades Inc. sales office.

les matériaux Cascades inc.

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Communigraph

ANNEXE E

Résultats des tests de la

Série de mesure #1

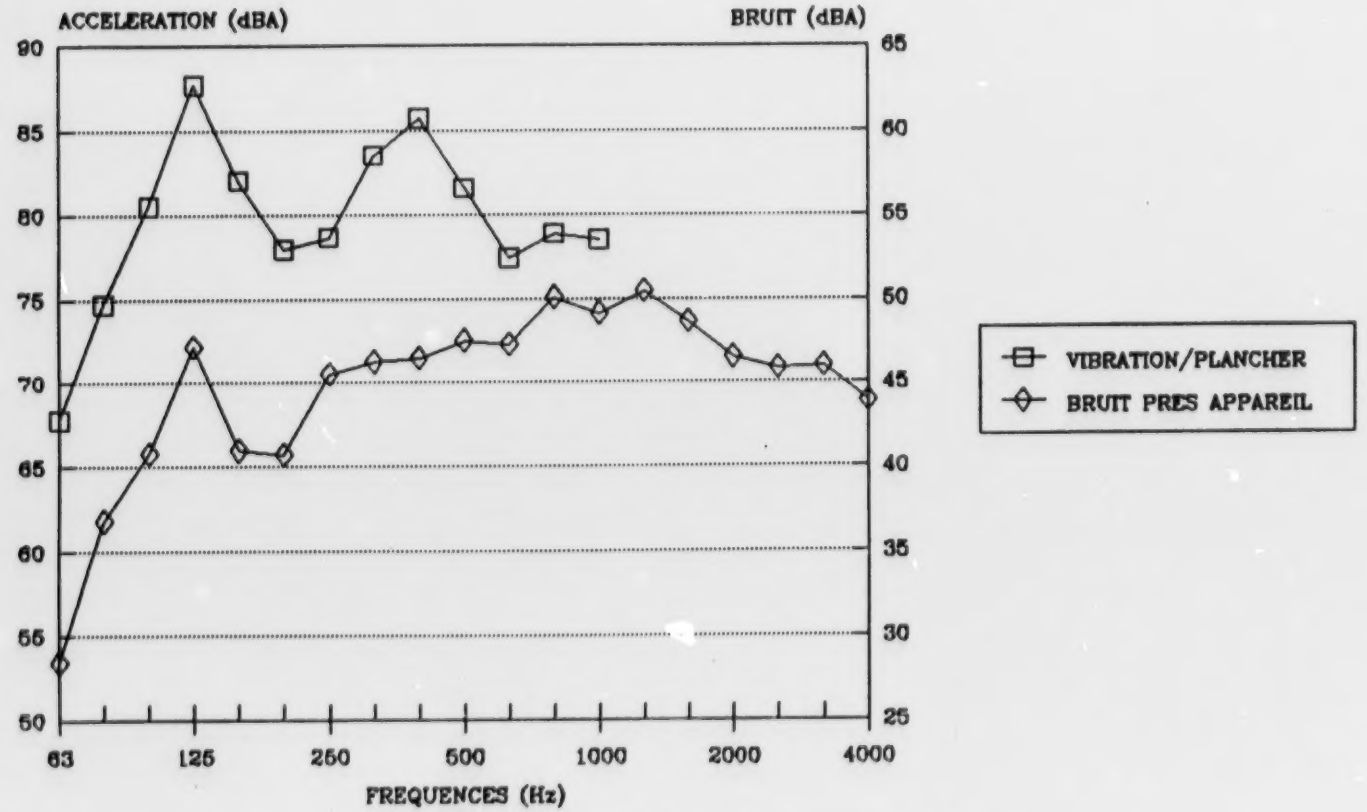

FIG. E1 – TEST SUR LA MACHINE A LAVER
SANS TRAITEMENT
(SERIE 1)

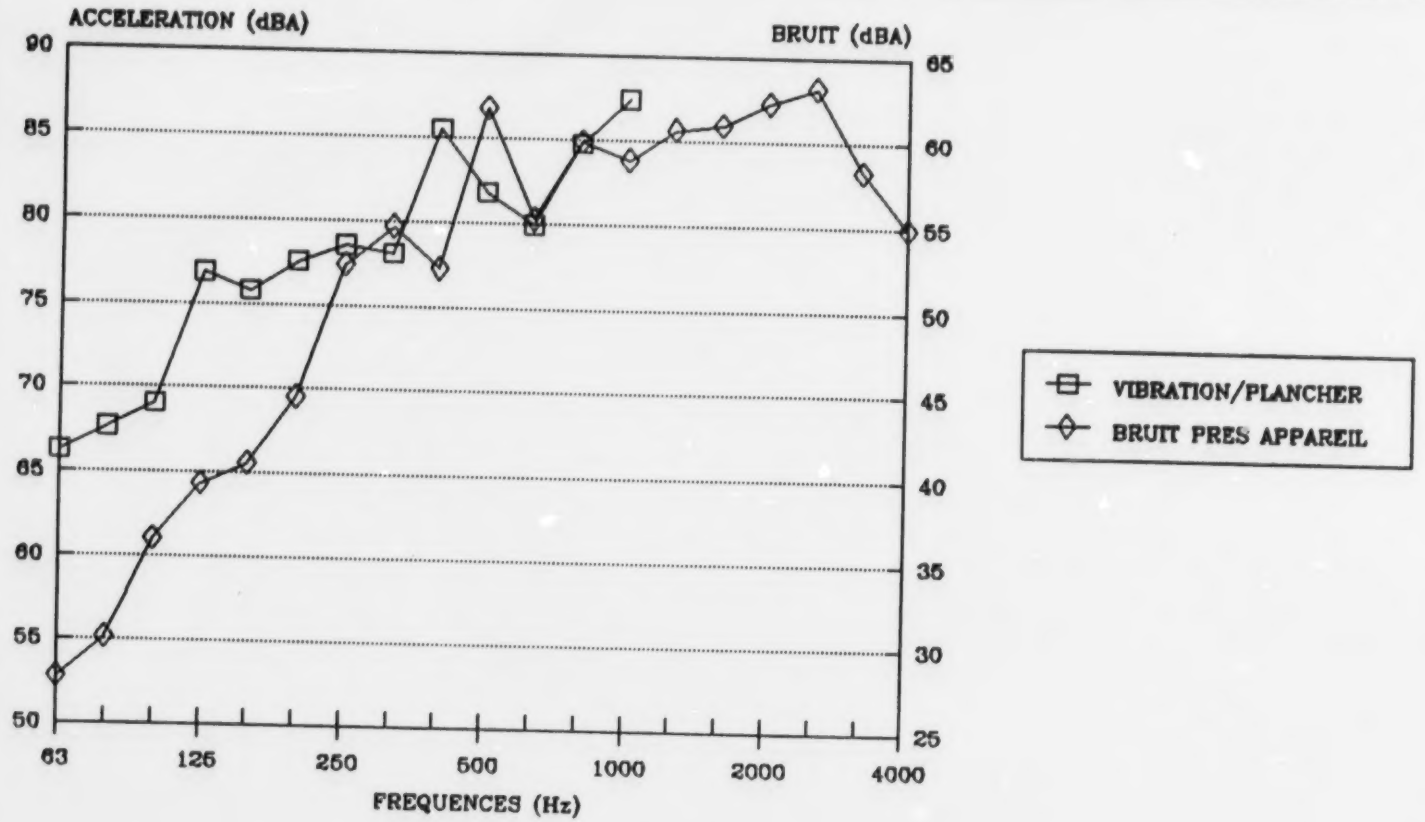

FIG. E2 – TEST SUR LA SECHEUSE
SANS TRAITEMENT
(SERIE 1)

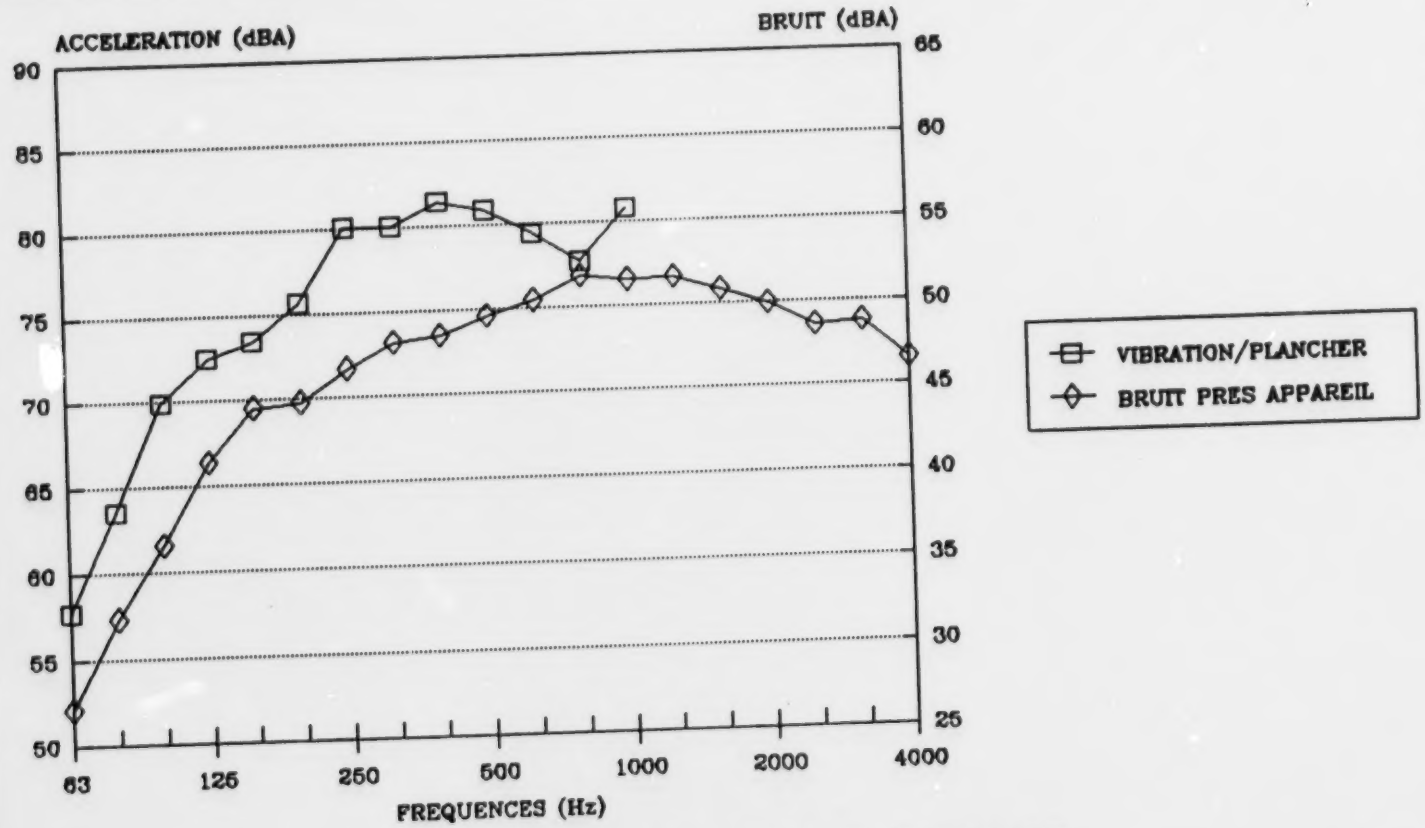

FIG. E3 – TEST SUR LE LAVE–VAISSELLE
SANS TRAITEMENT
(SERIE 1)

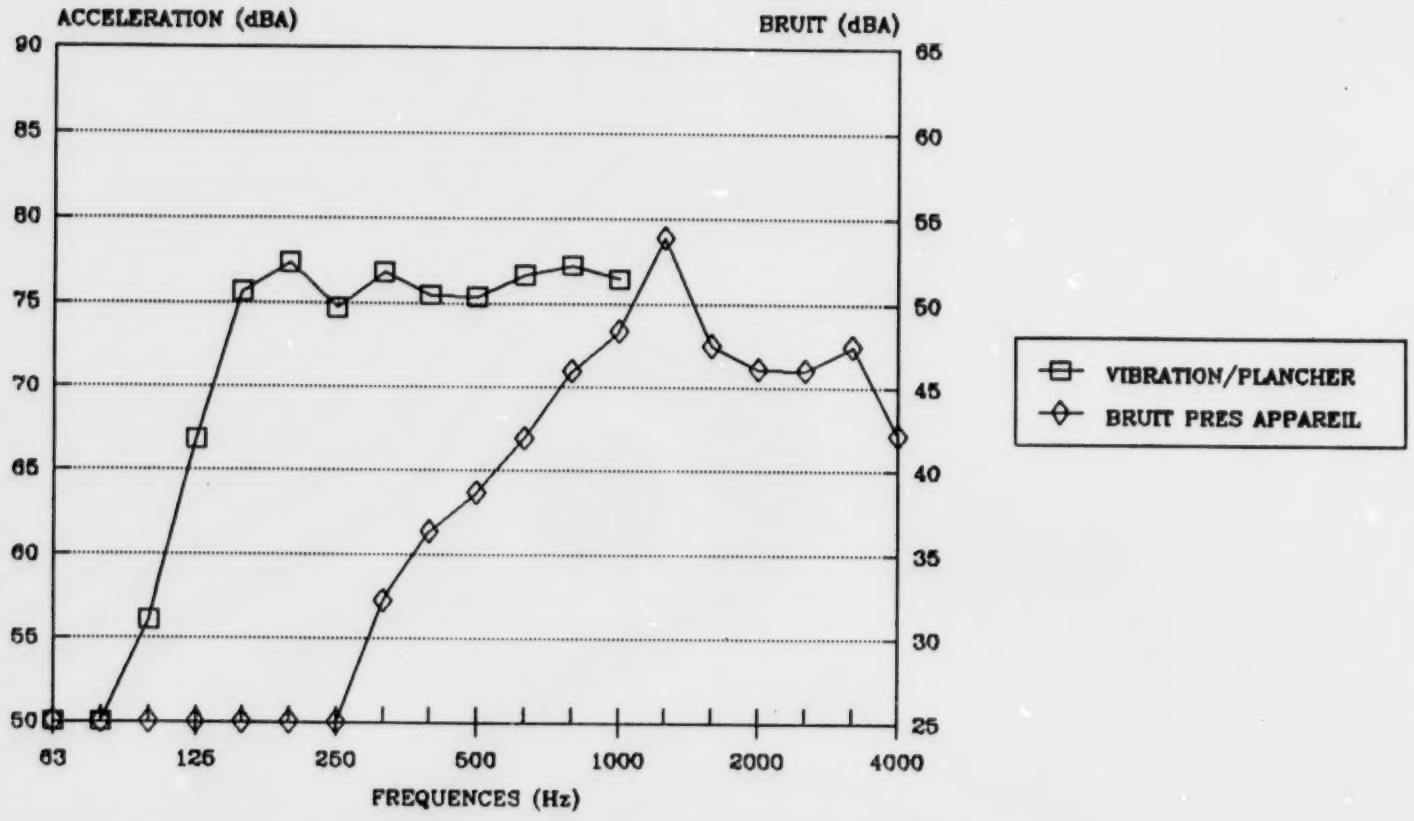

FIG. E4 – TEST SUR LE BAIN
SANS TRAITEMENT
(SERIE 1)

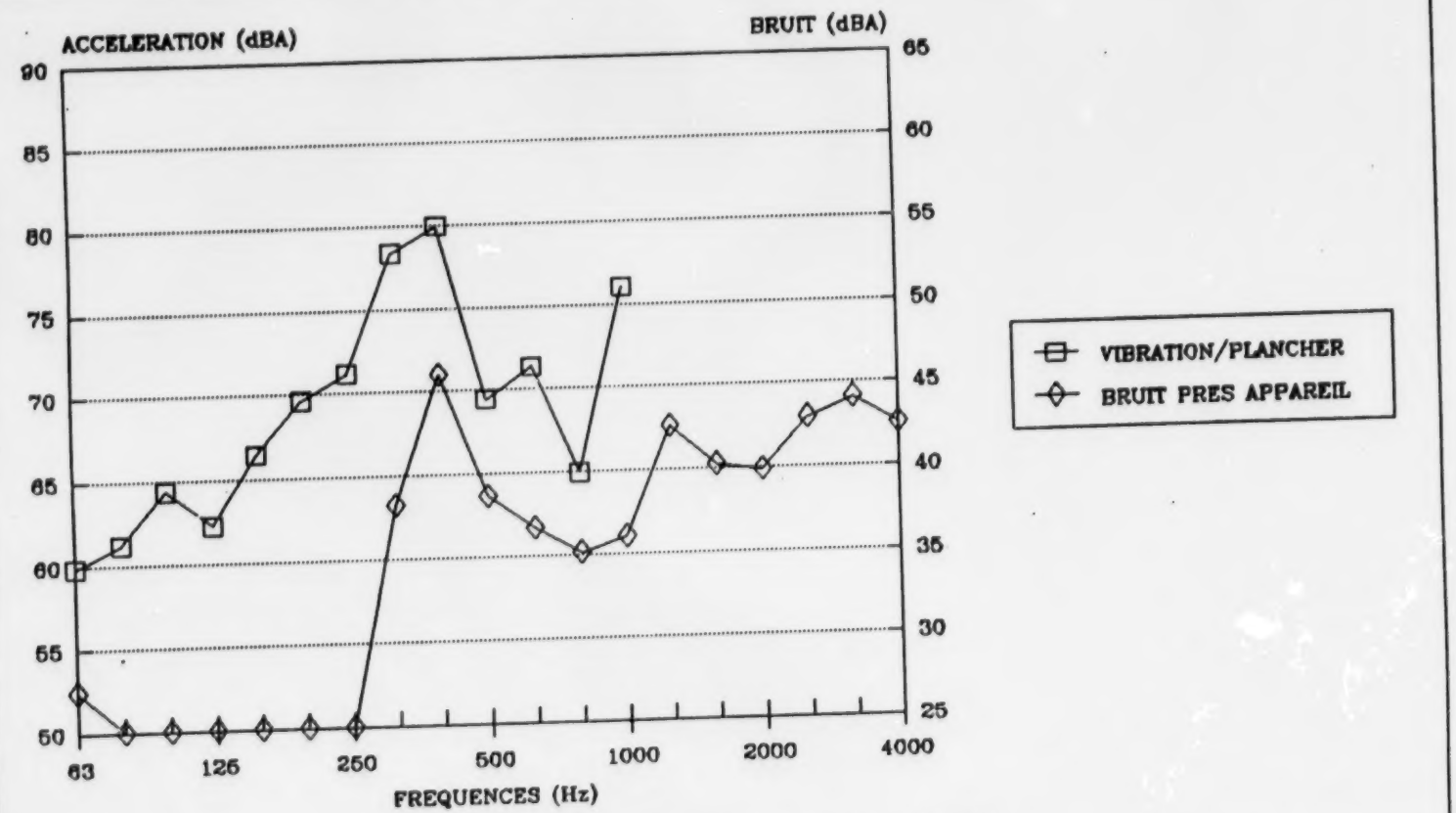

FIG. E5 – TEST SUR LA TOILETTE
SANS TRAITEMENT
(SERIE 1)

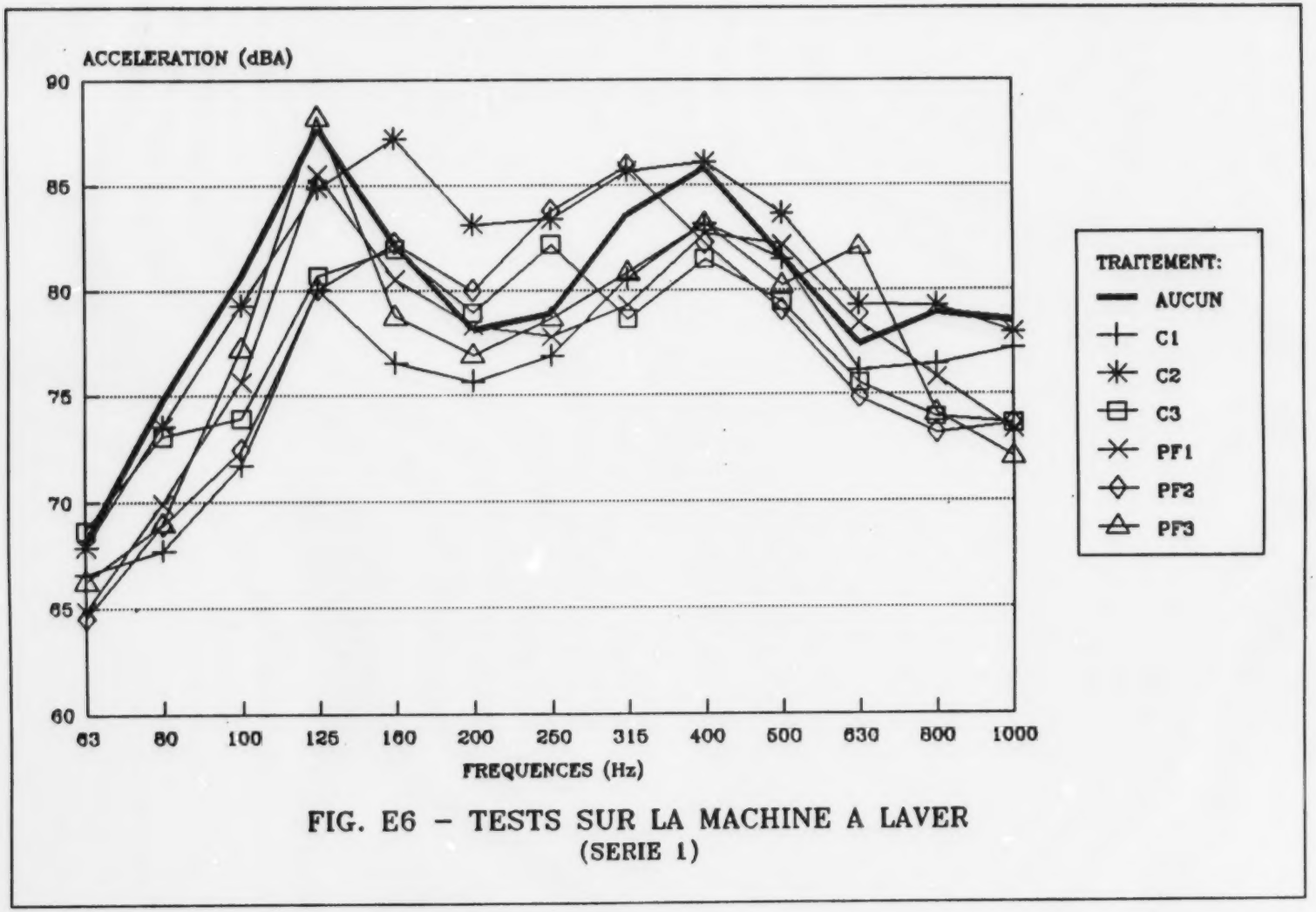

FIG. E6 – TESTS SUR LA MACHINE A LAVER
(SERIE 1)

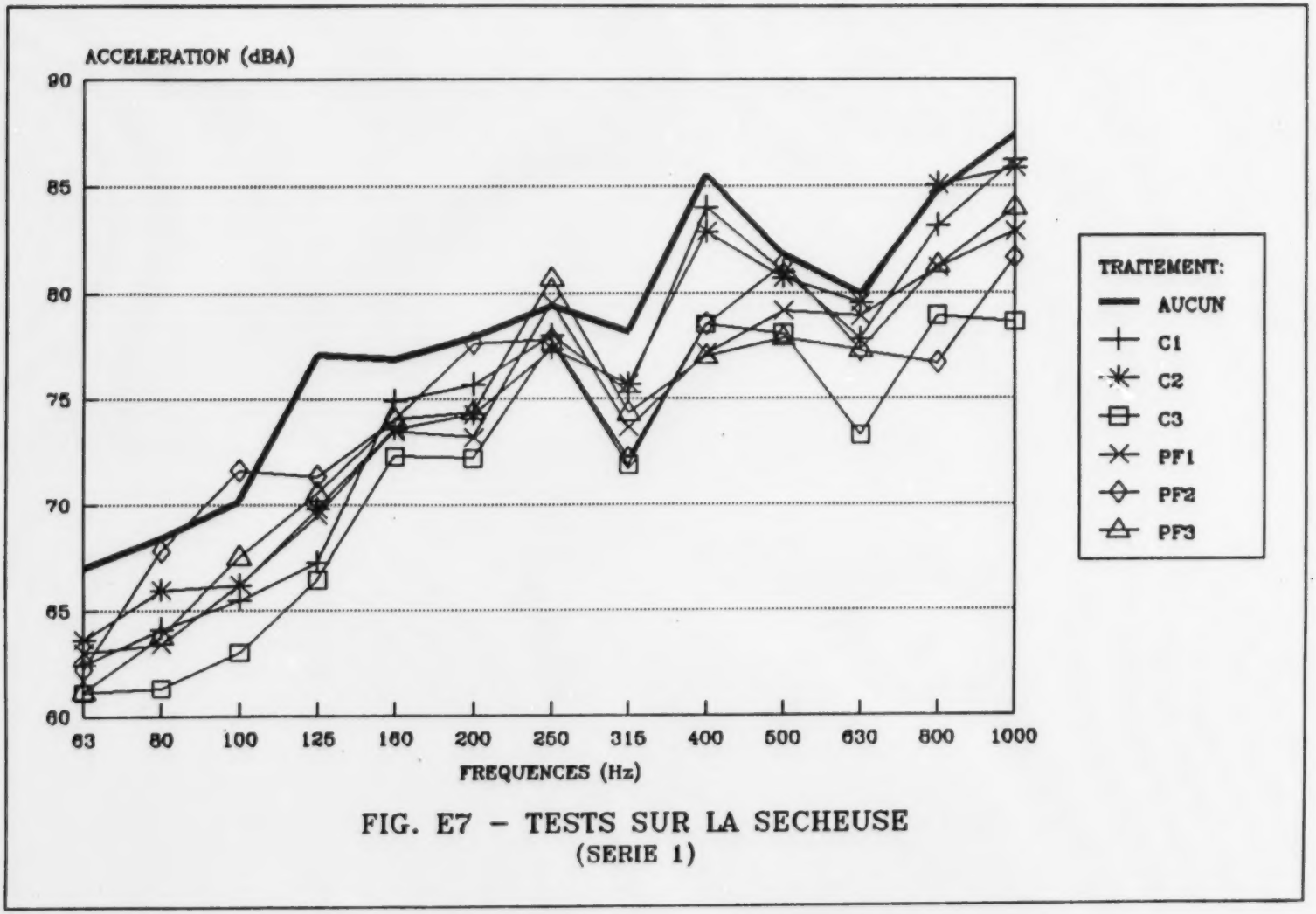

FIG. E7 – TESTS SUR LA SECHEUSE
(SERIE 1)

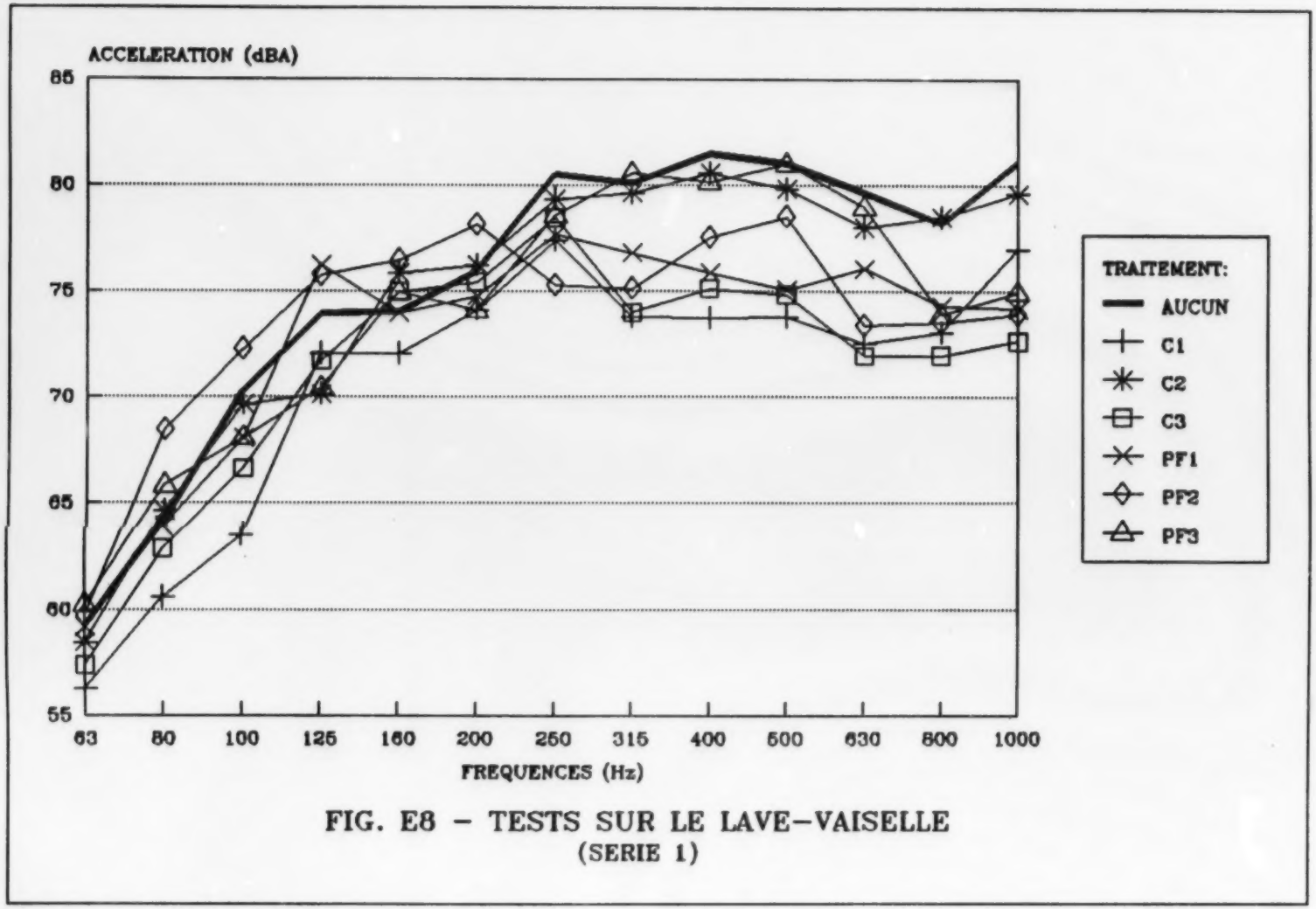

FIG. E8 – TESTS SUR LE LAVE–VAISELLE
(SERIE 1)

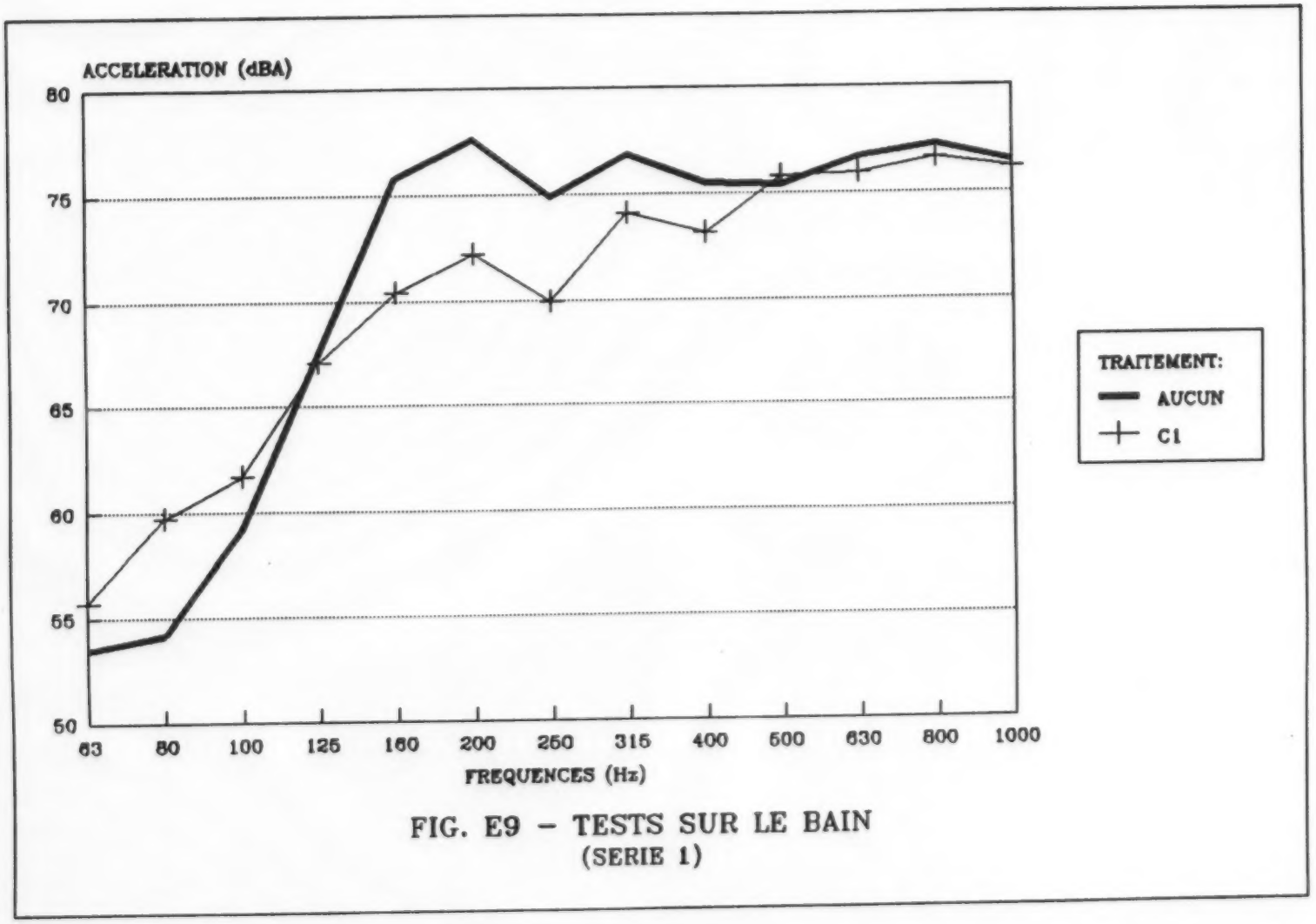

FIG. E9 – TESTS SUR LE BAIN
(SERIE 1)

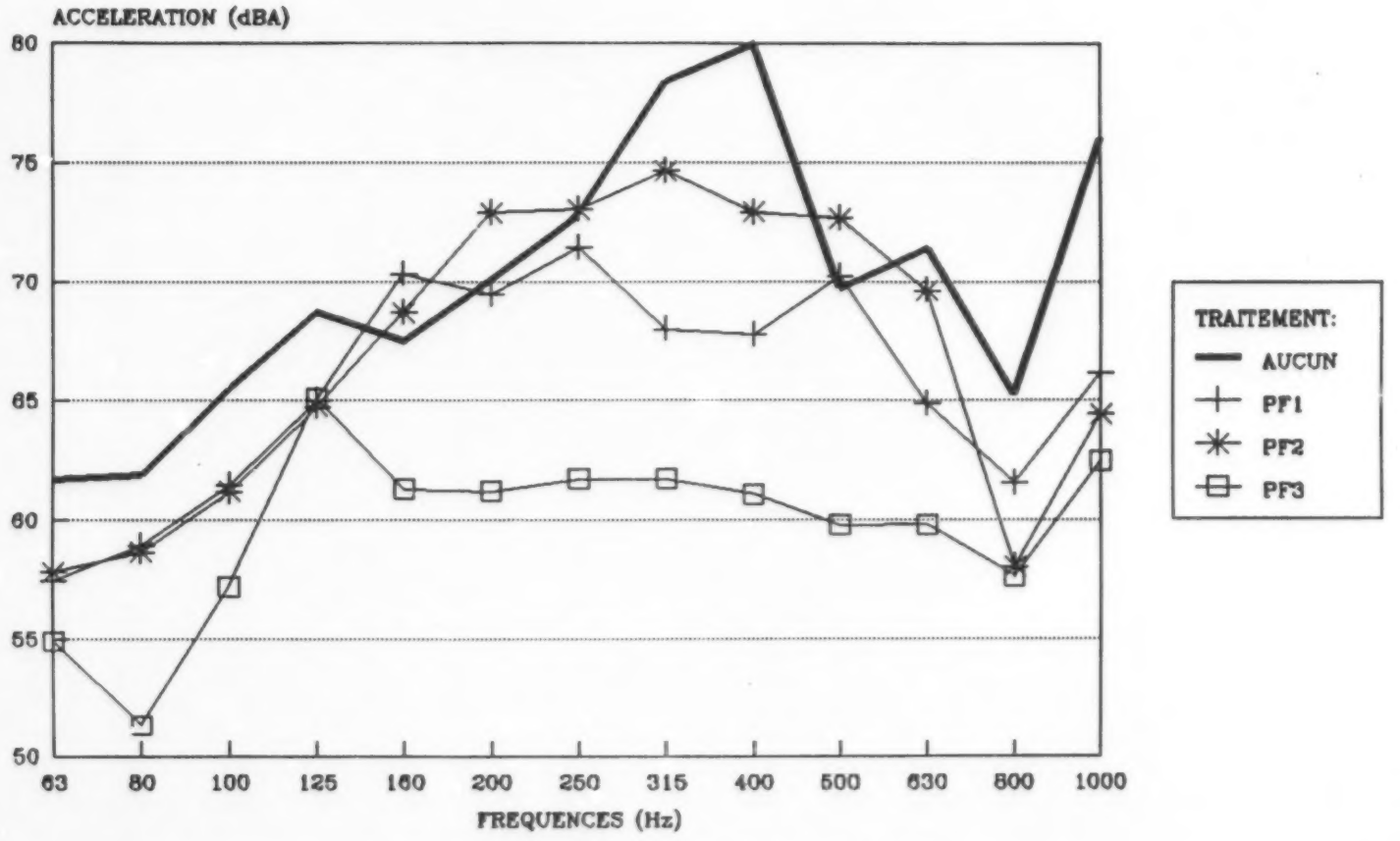

FIG. E10 – TESTS SUR LA TOILETTE
(SERIE 1)

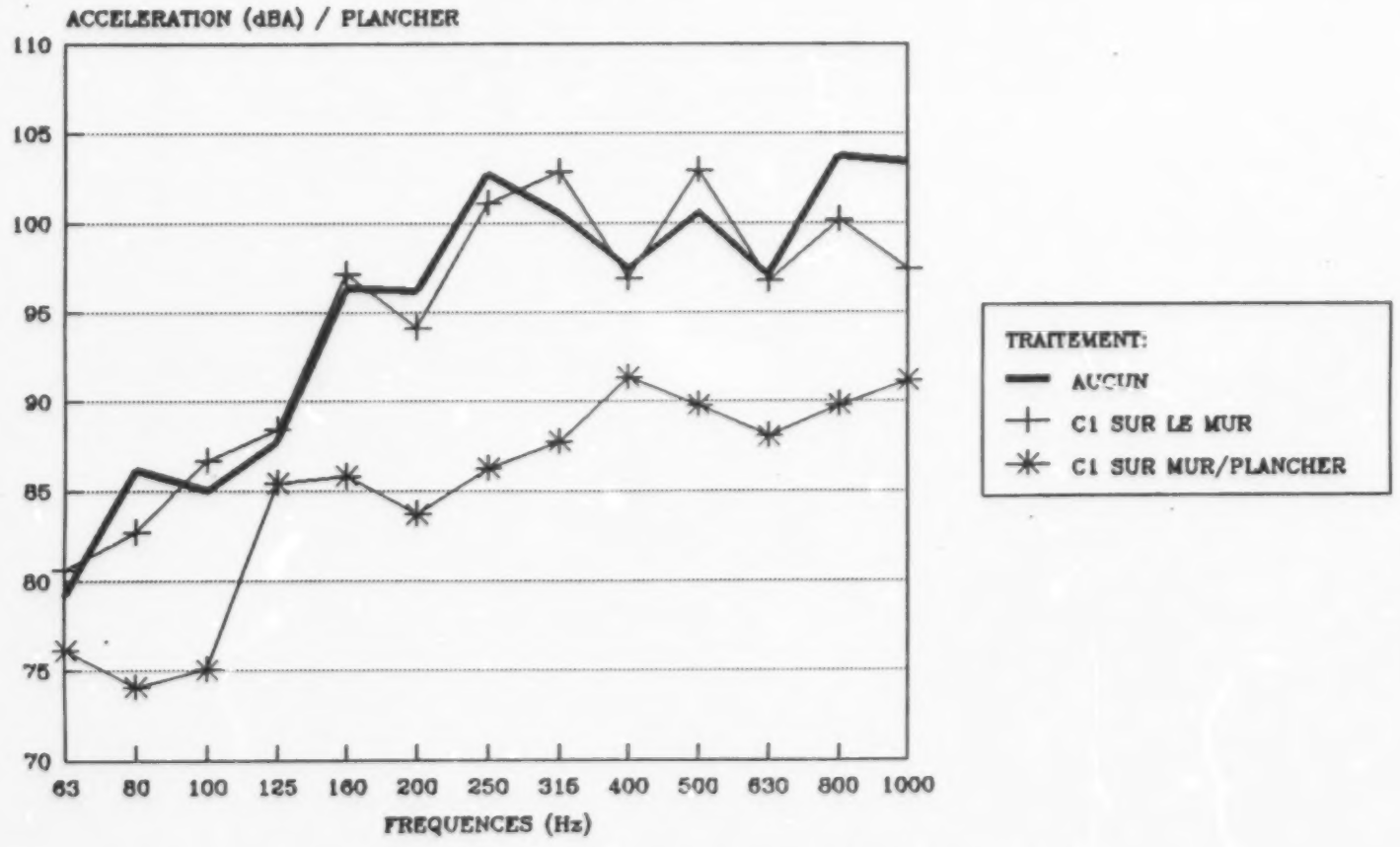

FIG. E11 – TESTS SUR LE COMPTOIR
(SERIE 1)

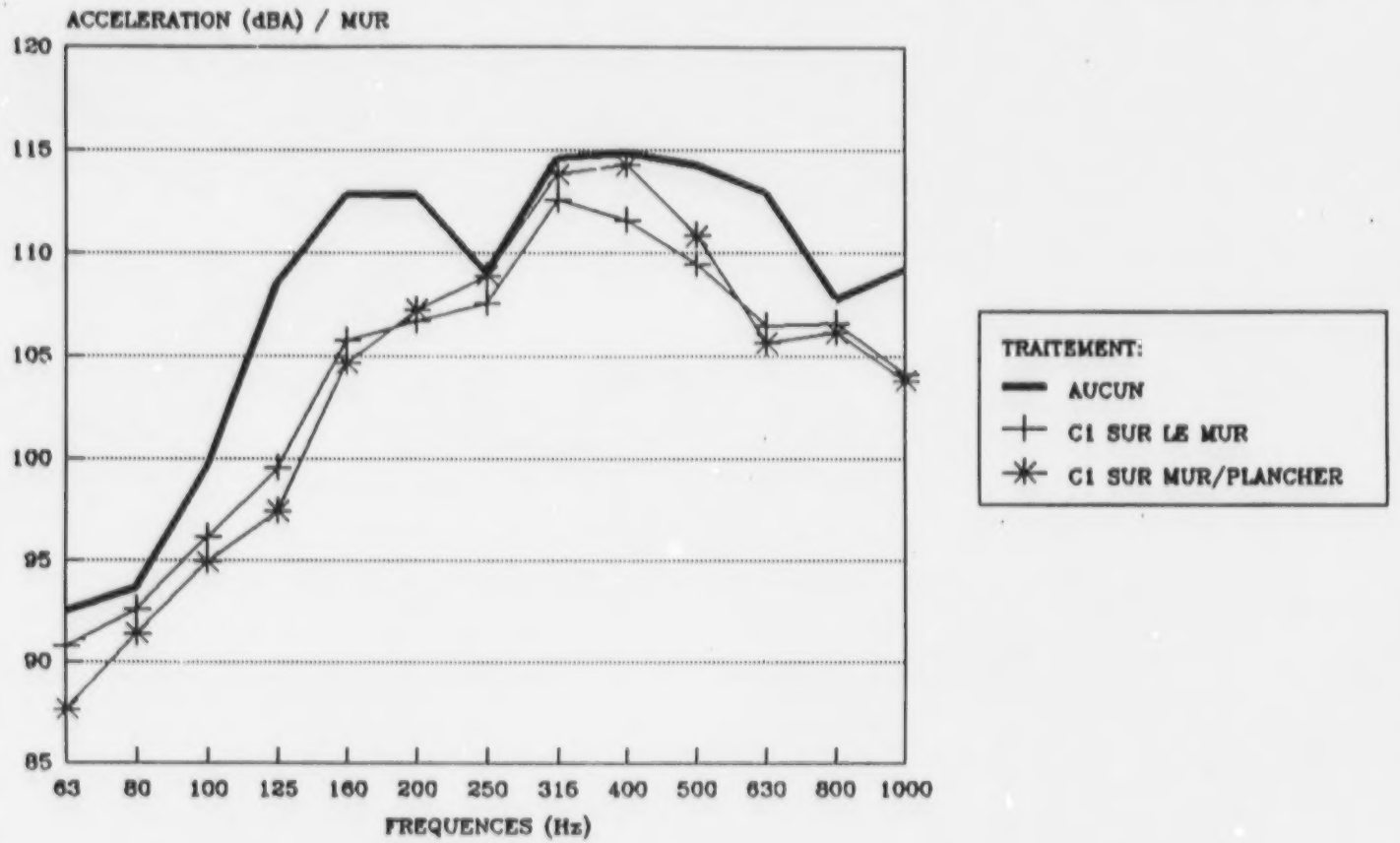

FIG. E12 – TESTS SUR LE COMPTOIR (MUR)
(SERIE 1)

ANNEXE F

Résultats des tests de la

Série de mesure #2

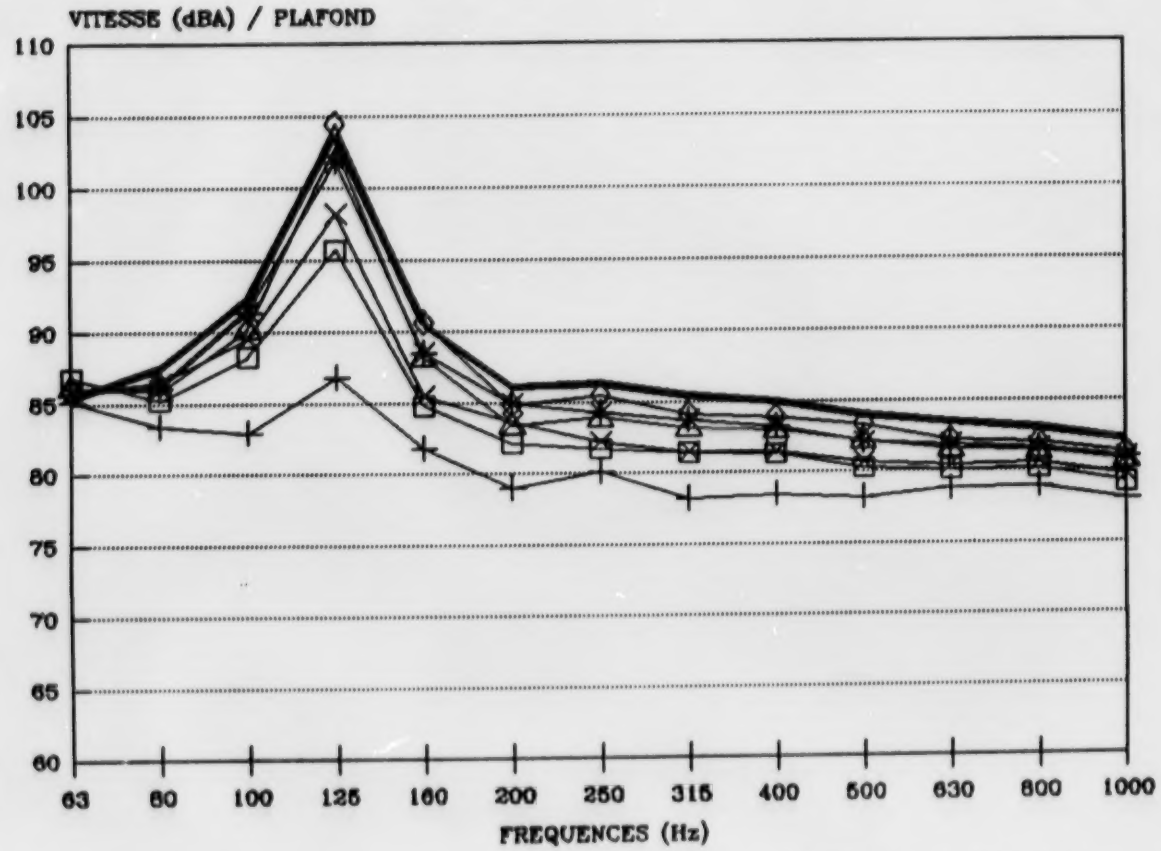

FIG. F1 – TESTS SUR LA MACHINE A LAVER
(Serie 2)

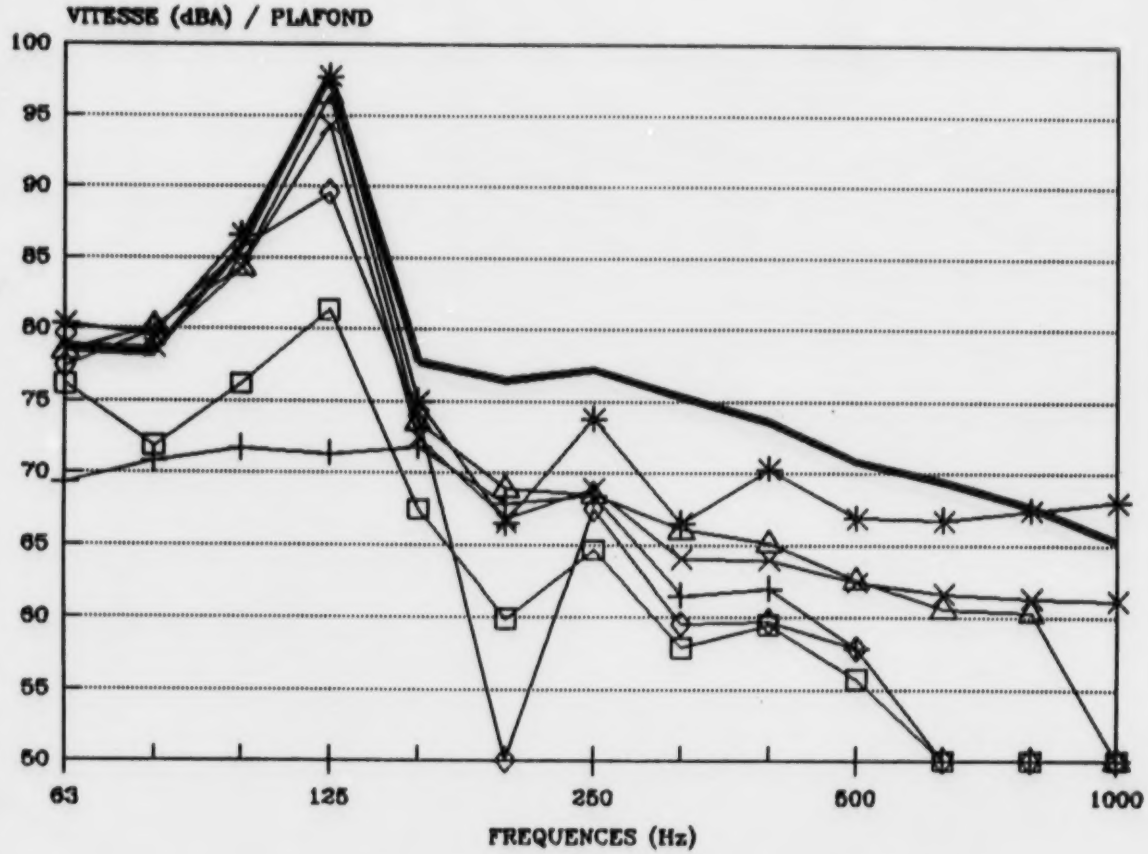

FIG. F2 – TESTS SUR LA SECHEUSE
(Serie 2)

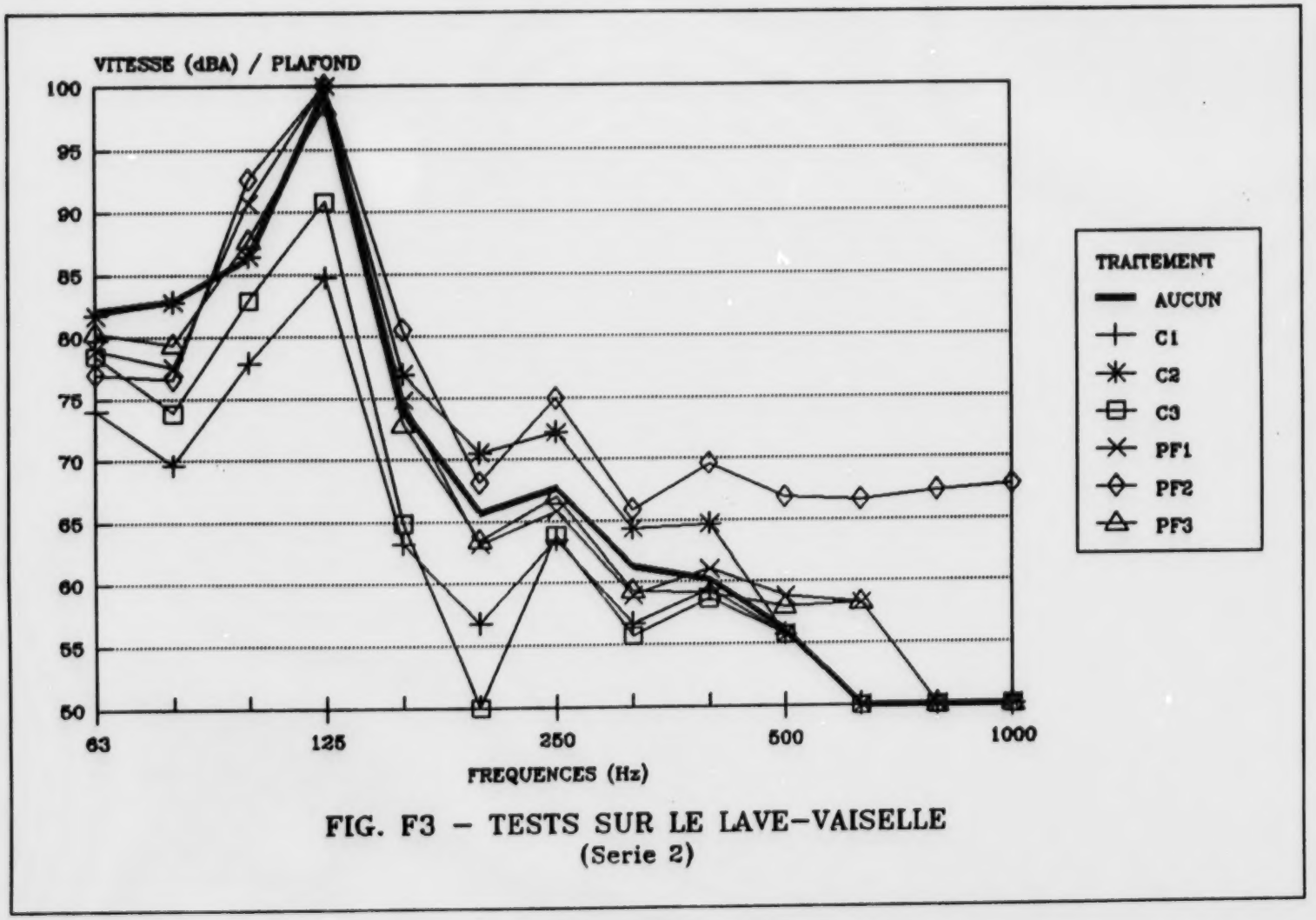

FIG. F3 – TESTS SUR LE LAVE–VAISELLE
(Serie 2)

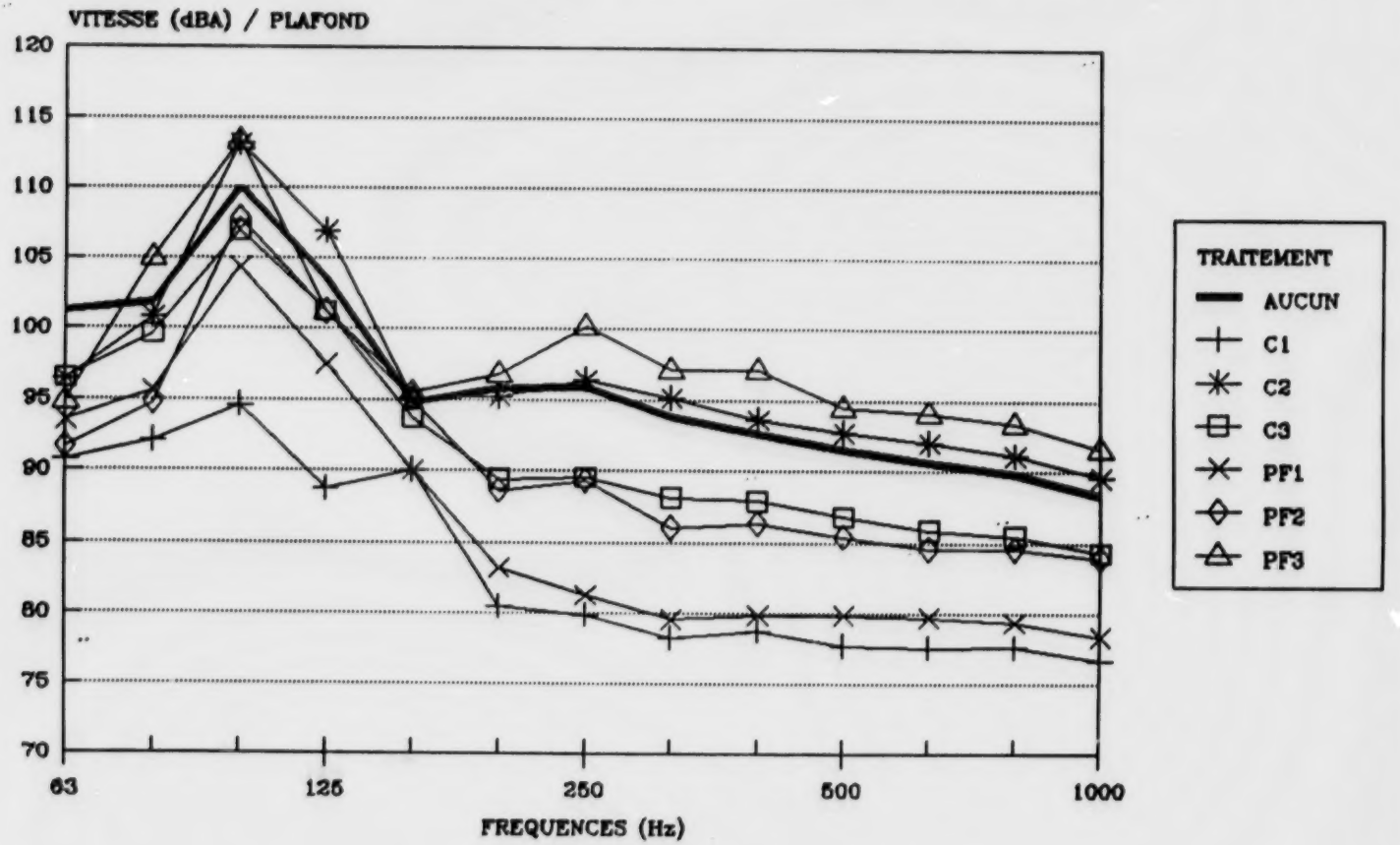

FIG. F4 – TESTS SUR LE COMPTOIR
(Serie 2)

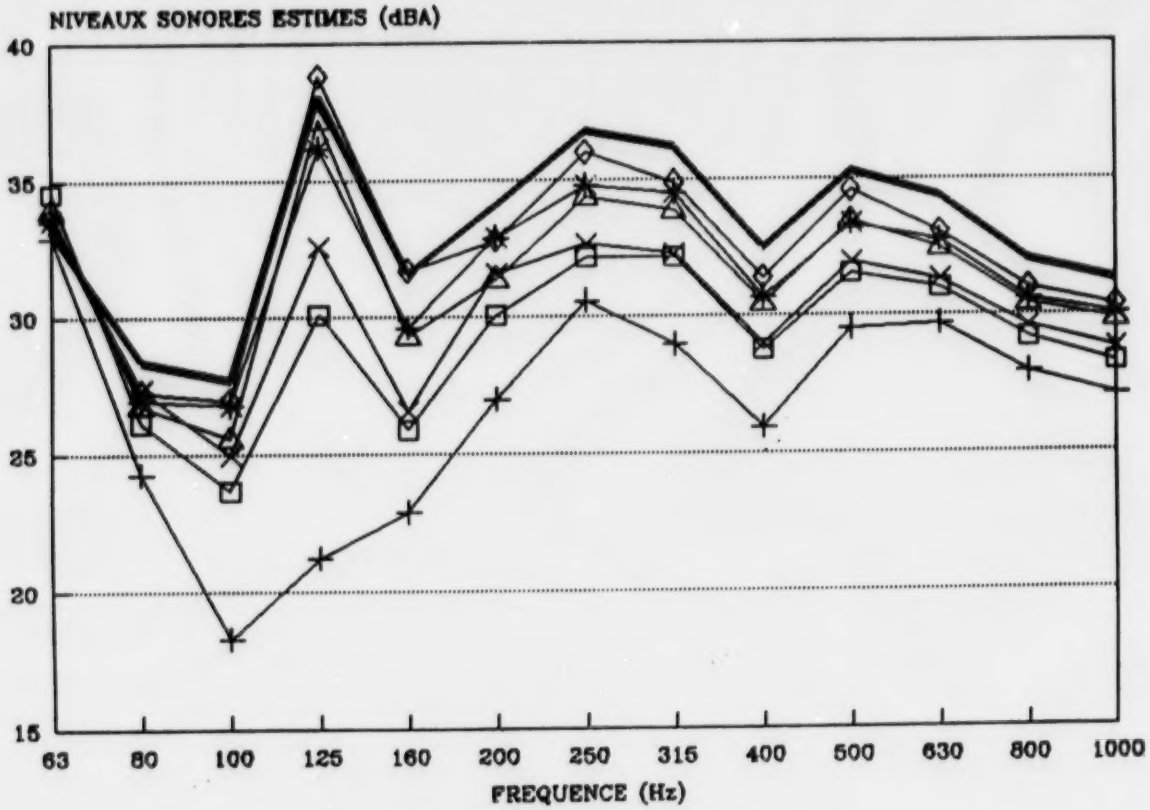

FIG. F5 – NIVEAUX SONORES ESTIMES
AVEC LA MACHINE A LAVER
(SERIE 2)

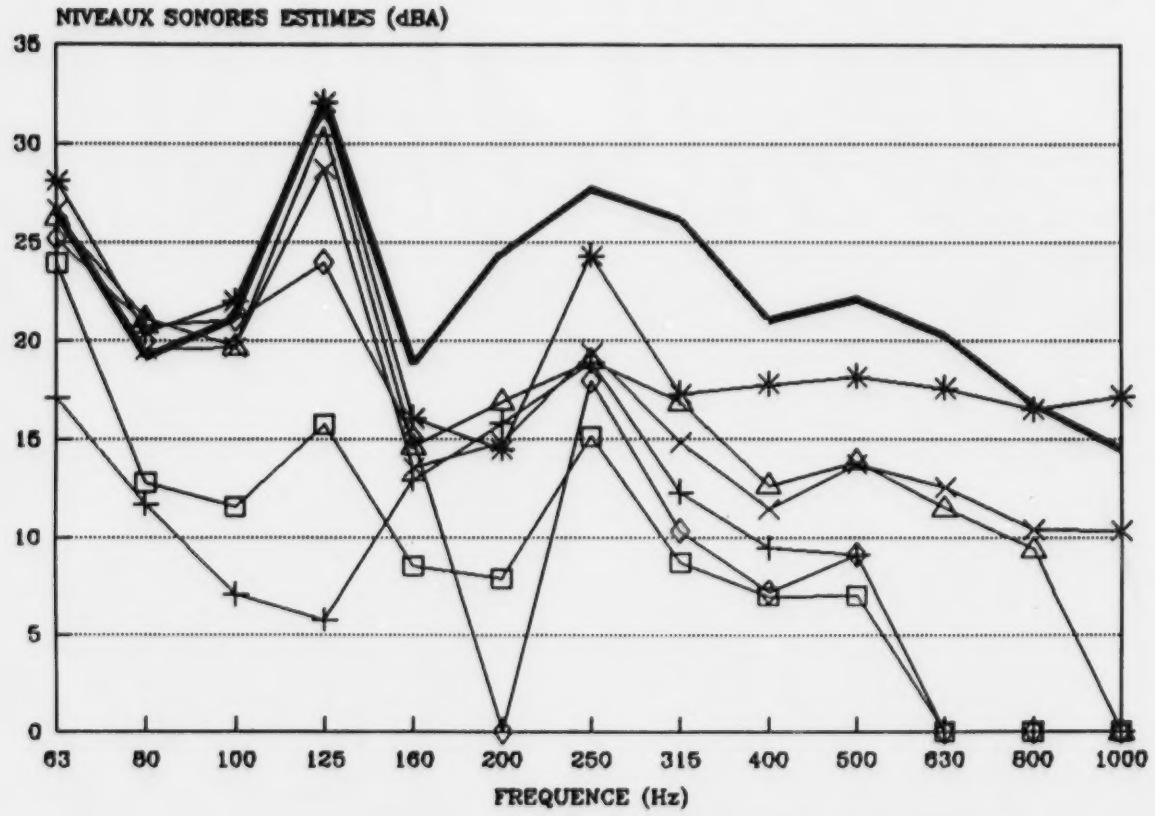

FIG. F6 – NIVEAUX SONORES ESTIMES
AVEC LA SECHEUSE
(SERIE 2)

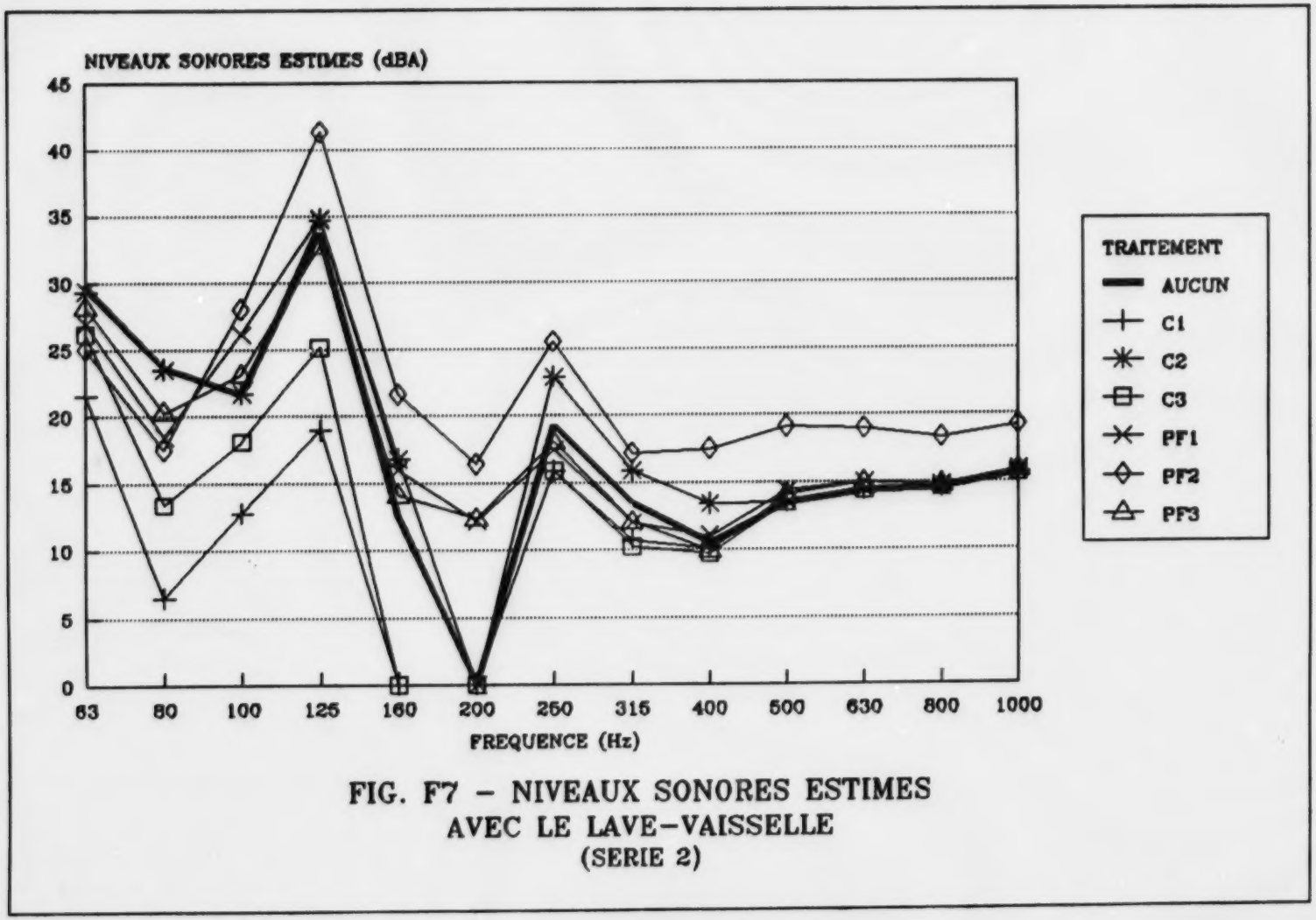

FIG. F7 – NIVEAUX SONORES ESTIMES
AVEC LE LAVE-VAISSELLE
(SERIE 2)

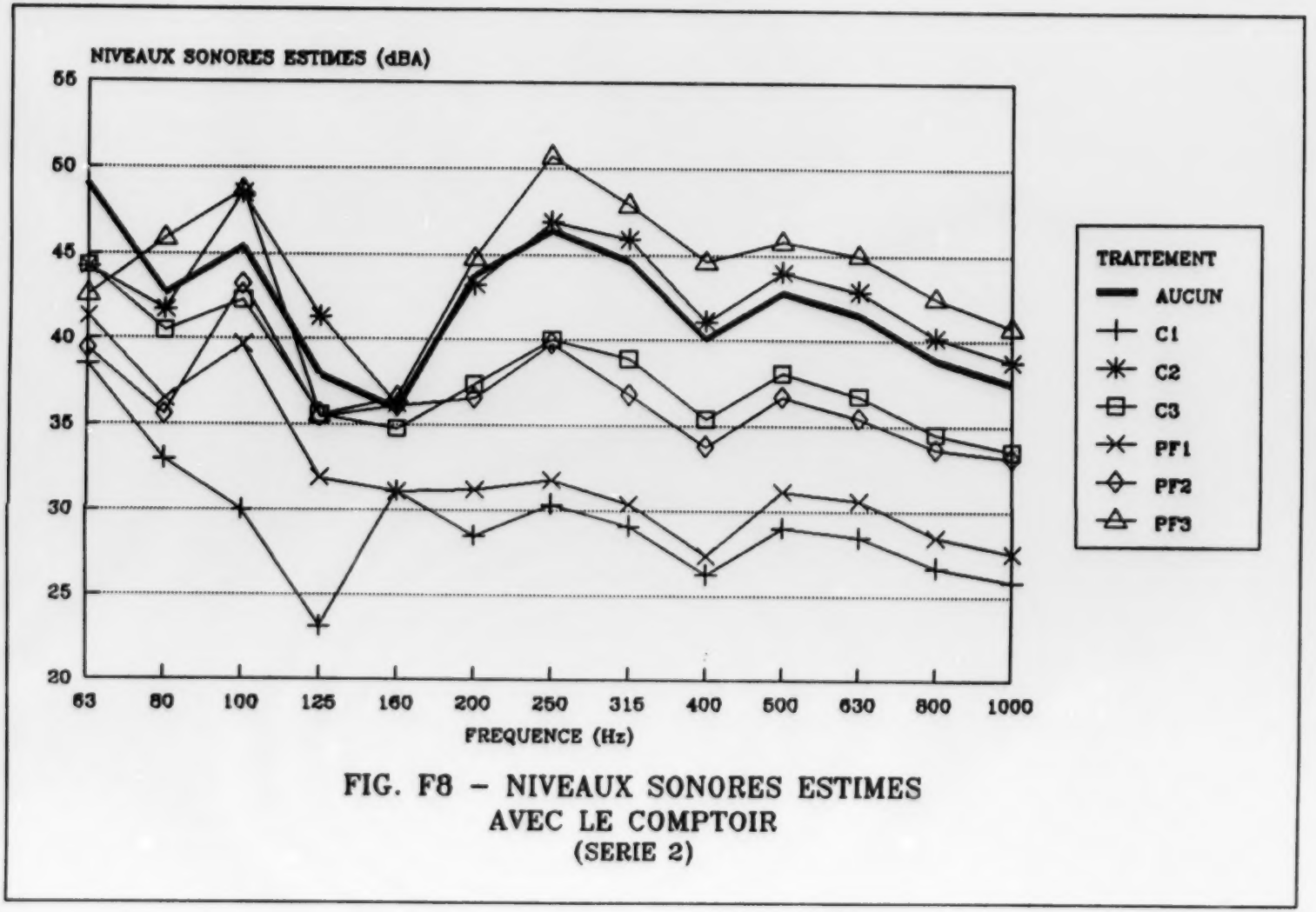

FIG. F8 – NIVEAUX SONORES ESTIMES
AVEC LE COMPTOIR
(SERIE 2)